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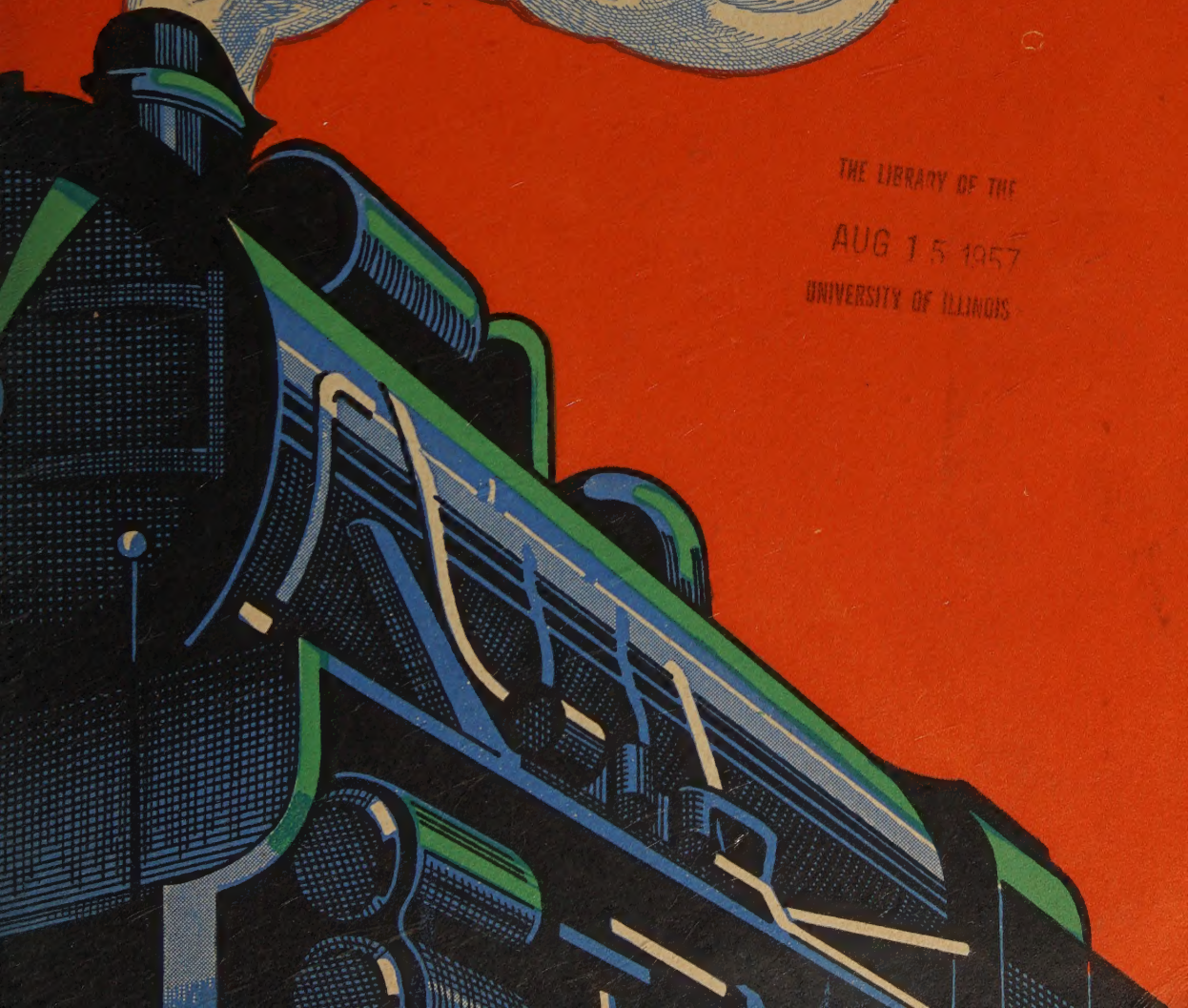
Monthly Bulletin of the International Railway Congress Association

(English Edition)



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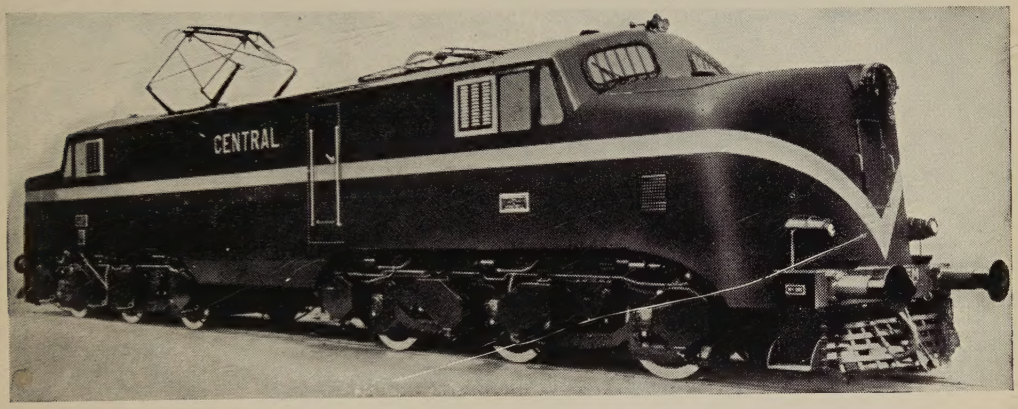

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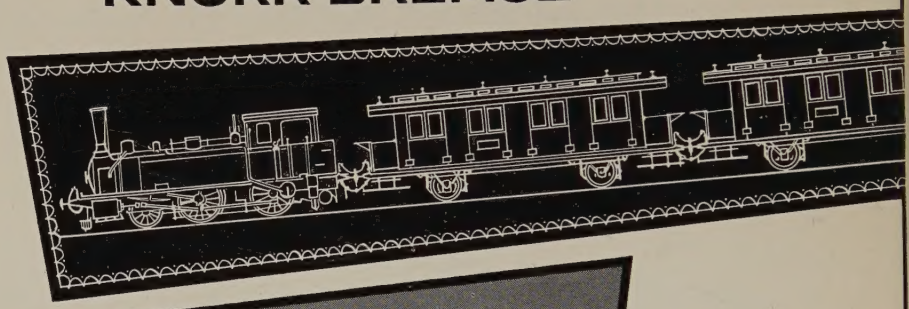

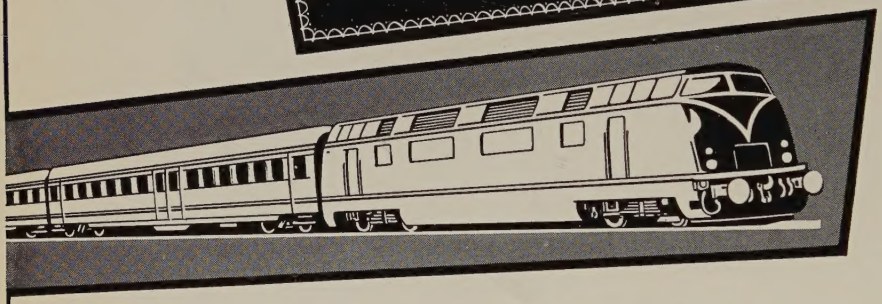

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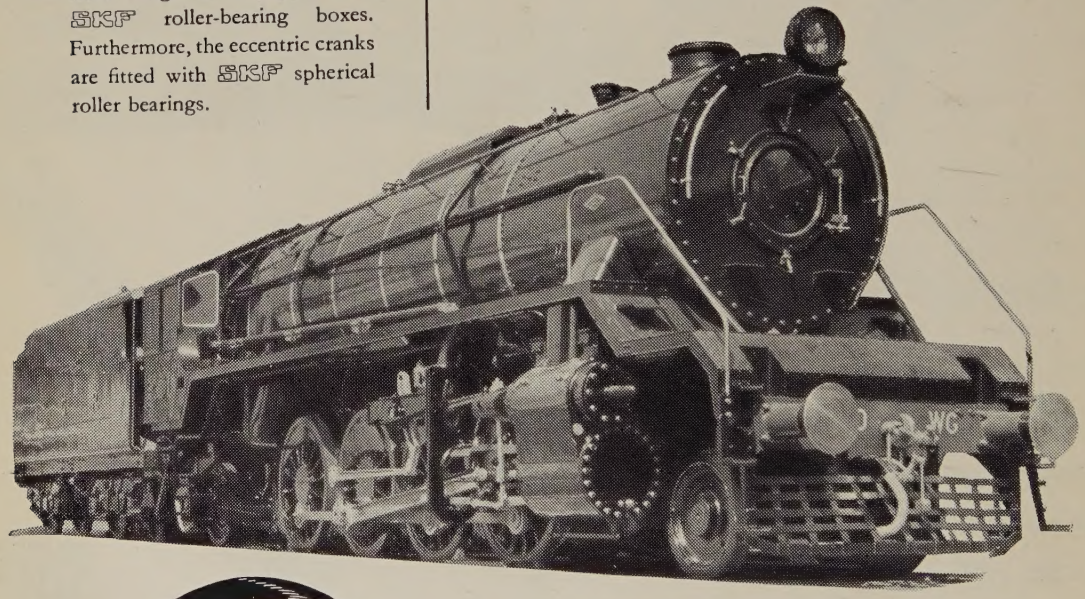

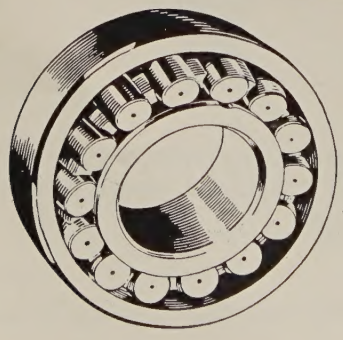

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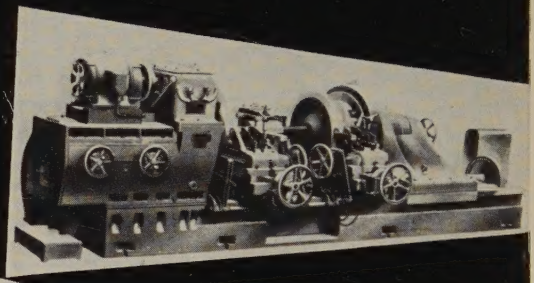

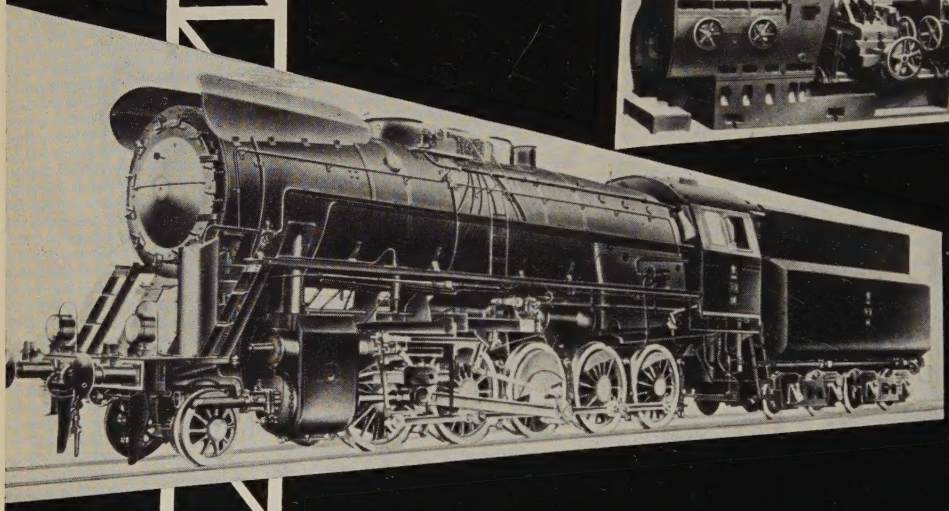

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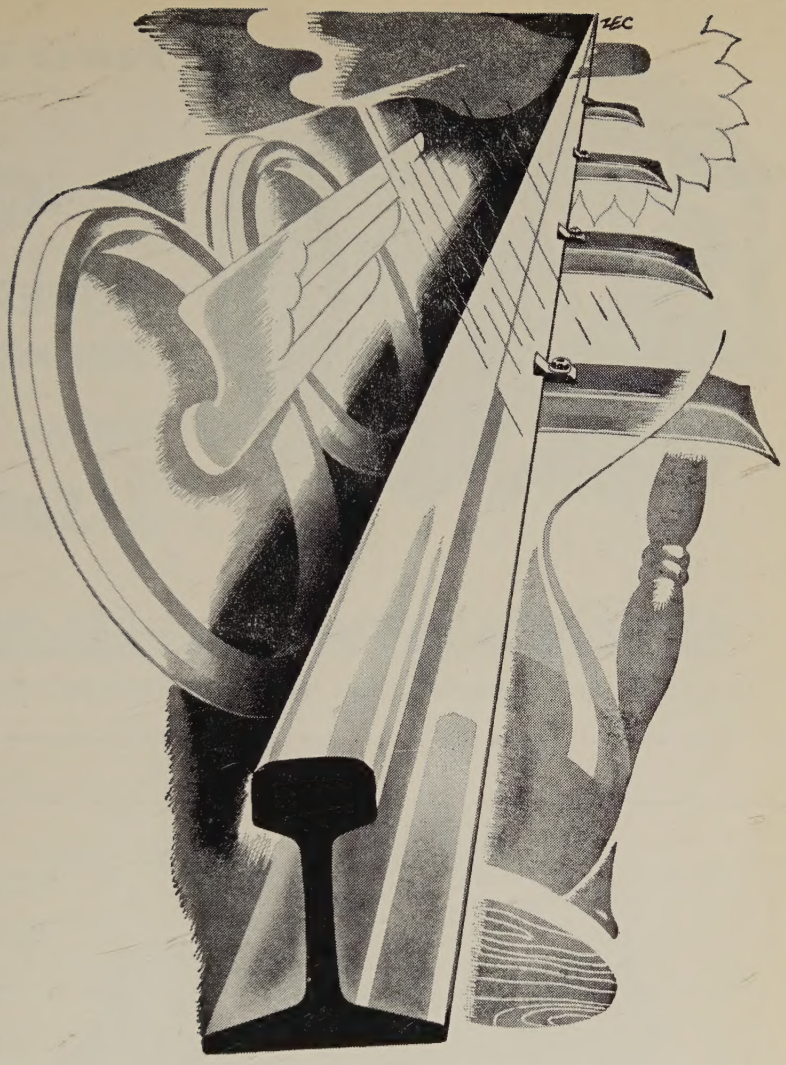

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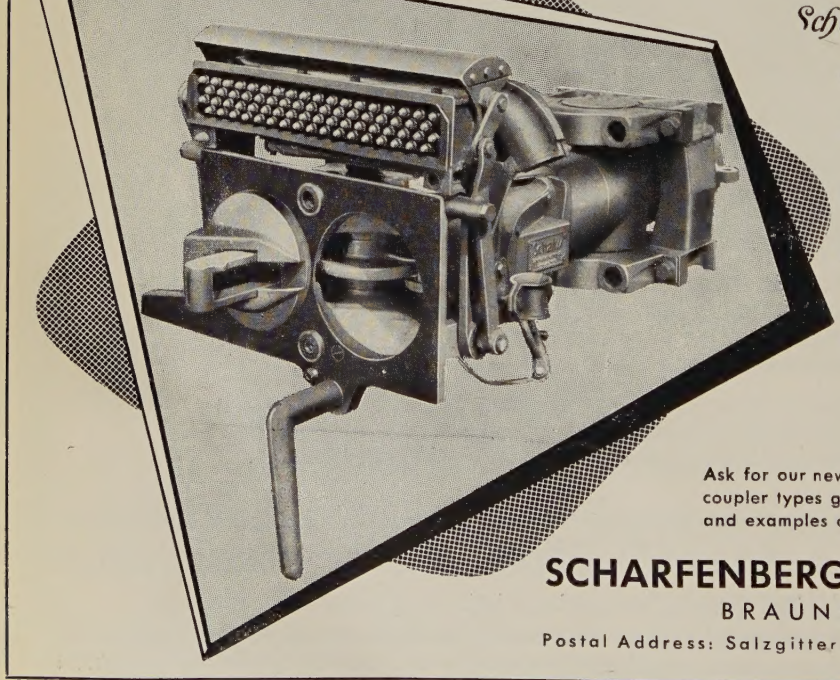

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MONTHLY BULLETIN

OF THE

INTERNATIONAL RAILWAY CONGRESS ASSOCIATION

[385 (05]

VOL. XXXIII. — 1956.

NOTICE TO READERS

LIST OF ABBREVIATIONS OF MEASURES, ETC., USED IN THE *BULLETIN*

Kilometre	km
Metre	m
Centimetre	cm
Square kilometre	km^2
Square metre	m^2
Square centimetre	cm^2
Hectare	ha
Are	a
Centiare	ca
Cubic metre	m^3
Cubic centimetre	cm^3
Stere	st
Hectolitre	hl
Litre	l
Centilitre	cl
Degree	°
Minute	′
Second	″
Tonne (Metric)	t
Ton (English)	ton
Hundredweight	cwt
Kilogramme	kg
Gramme	g
Centigramme	cg
Hour	h
Minute	min
Second	s
Kilogrammetre	kgm
Volt	V
Millivolt	mV
Kilovolt	kV
Ampere	A
Kiloampere	kA
Milliampere	mA
Kilowatt	kW
Kilowatt-hour	kW-h.
Watt	W
Megohm	MΩ
Ohm	Ω
Ampere-hour	Ah
Microfarad	μF
Henry	H
Weber	Wb
Hertz	Hz
Calory	Cal
Kilo-calory	kcal
Lumen	lm
Lux	lx
Horse-power	HP
Per cent	%
Per thousand	‰
Tonne-kilometre	tkm
Passenger-kilometre	p.-km
Train-kilometre	tr.-km
Miles per hour	m.p.h.
Franc	fr
Lire	L
Pound sterling	£
Shilling	s.
Penny	d.
Dollar	$
Cent	ct
Deutsche Mark	DM
Pfennig	pf

MONTHLY BULLETIN

OF THE

INTERNATIONAL RAILWAY CONGRESS ASSOCIATION

(ENGLISH EDITION)

PUBLISHING and EDITORIAL OFFICES : 19, RUE DU BEAU-SITE, BRUSSELS

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LIBRARY

OF THE

Permanent Commission of the International Railway Congress Association

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An edition in French is also published.

Vol. XXXIII. — No. 1. January 1956.

BULLETIN
OF THE
INTERNATIONAL RAILWAY CONGRESS
ASSOCIATION
(ENGLISH EDITION

[656 .23]

INTERNATIONAL RAILWAY CONGRESS ASSOCIATION

ENLARGED MEETING OF THE PERMANENT COMMISSION
(THE HAGUE-SCHEVENINGEN, 1956.)

QUESTION 3.

Development of railway tariffs.
Economic justification of these tariffs.
Adjustment of tariffs to the new conditions of the general economic system and to the competition of the other forms of transport.
Function of tariffs in coordination of inland transports.

REPORT

(America (North and South), Australia (Commonwealth of), Burma, Ceylon, Egypt, Finland, Germany (Federal Republic), India, Indonesia, Irak, Iran, Republic of Ireland, Japan, New Zealand, Norway, Pakistan, South Africa, Sudan, Sweden, United Kingdom of Great Britain and Northern Ireland and dependent overseas territories),

by Dr. O. Maier,

Hauptverwaltungsrat, Referent für Internationales Eisenbahnfrachtrecht und für Internationale Güter- und Tiertarife der Hauptverwaltung.

I

The study of this question was suggested by the French National Railways and the Italian Railways. The reason given was that the great number of scales of charges and classifications of goods in the various European countries is the source of continuous difficulties when economic studies must be made.

II

This report is based on the replies received on the questionnaire from the railways or railway organisations of the following countries :

Burma, Ceylon, East Africa, Egypt, Germany (Federal Republic), Great Britain, India, Iraq, Ireland, Italy, Japan, New Zealand, New South Wales, Norway, Sweden, Tasmania, United States.

The analysis made is subject to certain reserves because the information furnished are not always quite clear.

III

The present situation of the railways in relation to the general economic situation of the country.

A. — *Passenger traffic.*

Distinction between ordinary and special fares is made by all railways except the Iraqi, Indian and East African Railways, whose ordinary fares show a specific structure.

The differentiations according to classes within the category of ordinary fares vary considerably. Thus, the London Transport Executive and the Tasmania Government Railways apply ordinary fares for one class only. Other railways have two or three classes, the Indian Railways as many as six. The ratio between the third and the second class ranges between 1 : 1.2 and 1: 6. Some railways charge an extra fee besides the ordinary fare for fast trains, specially equipped coaches (air conditioned coaches, etc.) and other special services. The Iraqi State Railways charge different fares for day and night trips, the fares for night trips being 25 % above those for day trips. Sleeping car accommodation is included in their first class fare. As far as the East African Railways are concerned, it is noteworthy that whilst their first and second class fares are based on a fixed charge per mile, their third class fares have an element of taper in them.

As a rule the basic charges are not determined in accordance with the specific prime cost attributable to passenger train traffic. Many Railways do not compute them at all. A certain exception is made by the Class I Railroads of the A. A. R. who are under obligation to prepare separate costings for freight and passenger traffic. Their passenger tariffs, however, owing to the competition by other carriers, failed to meet the full costs of this category of traffic. In other countries the level of the basic charges and their differentiation is determined by certain average costs, based on estimates rather than on accurate calculations, and by general considerations of a social and commercial nature (satisfaction of travel requirements, differences in accommodation facilities and standards of confort). This implies that factors of prime cost are also taken into consideration to a certain extent. All railways revise their fares from time to time to adjust them to changed conditions brought about by the general increase of costs, as far as the competitive situation and other considerations permit. The fares are partly computed by multiplying the fixed basic rate (per kilometre or per mile respectively) with the distance and partly by applying various systems of tapering rates. No tapering rates are applied for example by the German Federal Railway (except in the case of return tickets and various fare reductions), by the Iraqi State Railways (on account of the short distances involved), the Ceylon Government Railway and the New Zealand Government Railways. Pronounced tapering is applied by the Japanese National Railways, whose index figures fall from 100 to 46 for distances rising from 100 to 1 500 km. The arguments in favour of tapering passenger fares are : encouragement of long distance travel and, in metropolitan traffic (London Transport Executive), recognition of the progressive burden upon travellers as their homes are further from their place of work, as well fostering the even spread of the population.

A similar variety exists in regard to special fares. Special fares are granted to promote sales or on social or cultural

grounds, commutation fares playing a predominant part. The special fares are computed either in terms of percentages of the ordinary fare or in accordance with particular rate fixing principles. Special fares are often being tapered, in fact more frequently than ordinary fares. Not everywhere does the application of social tariffs infuence the general revenue to a noticeable degree, although in the case of some railways the share of these tariffs is very high, ranging between 10 and 20 % of the revenue of the total traffic, the corresponding traffic performances naturally being much higher. Most heavily affected are the German Federal Railway, the Japanese National Railways and the London Transport Executive. These are the very railways who receive no compensation for their loss in revenue, whereas other railways who obviously grant social tariffs on a much smaller scale (e. g. the State Railways of New South Wales and Tasmania) are indemnified. Tariff reductions of such proportions can only be regarded as justified from a superior national viewpoint and losses thus incurred by the railways should consequently be reimbursed by the State Treasury.

The railways of all countries seem to share in the growth of the economic prosperity of their country, as far as this growth is reflected in an increase of passenger traffic. An accurate picture of the size of this increase cannot be gained. In countries with a fully developed transport system, rail traffic has not increased in proportion to the general rise in traffic. Whilst, for instance, the total traffic of all carriers in the area of the Federal Republic of Germany increased from 100 to 198 between 1936 and 1954, the index figures relating to rail traffic fell from 100 to 71. Judging from the replies received, conditions prevailing in some East Asiastic countries as well as in East Africa are much more favourable. This question, of course, is closely related to that of competition from other means of transport, in particular from motor vehicles and — in countries with vast territories like U. S. A. — also from airplanes.

B. — *Freight traffic.*

A similar variety of tariffs exists in regard to freight traffic, though certain uniform lines are noticeable. As a rule, freight tariffs are divided into ordinary and exceptional tariffs, although the extent to which one or the other of these tariffs are applied varies considerably and a clear separation between these two groups is not possible. With all railways the obligations towards national economy play a particular role. Practically nowhere is the differentiation of rates influenced by seasonal or topographical conditions. The fixed kilometre charge is applicable throughout the year and, as far as the major railway systems are concerned, there are very few lines for which higher or lower rates are quoted in comparison to other lines. The value of the commodities according to a specific clasification system such as : raw materials (bulk goods), semi-finished products and finished products, are taken into consideration in all tariffs in some form or other, even though the principle of charging what the traffic can bear has gained greater importance in course of time. This applies, in particular, to such tariffs as have been created to make allowance for special conditions. The gap between the highest and the lowest rated commodities is generally very large. In some cases the ratio of discrepancy is 100 : 10 and even higher. Less pronounced is the principle of quantity with varying rates for instance for 5, 10, 15 or more tons. The foregoing remarks do not take into account the most recent development in Great Britain, which is dealt with in Chapter VI. Some railways have only established part-load rates and apply the next lower part-load class for wagon loads. Apart from these main elements,

some additional factors are taken into consideration in rate-making. The British Railways for example apply different rates for station to station, station to private siding and pickup and delivery traffic. Other tariffs are constructed with particular regard to loadability, regularity of shipments and transport risk. Apart from the Iraqi State Railways and the Ceylon Government Railways, who apply a fixed per kilometre charge, all railways quote more or less pronounced tapering rates. The same reasons are given to justify the adoption of the tapering system : encouragement of long distance traffic (particular stress being laid on the necessity of decentralizing industry) and diminution of the relative cost of transport with increasing distance. The tapering principle is applied in many different ways. A great number of railways have different individual tapering scales for their various classes of commodities, the rates for the low grade traffic often being but slightly tapered. The mileage zones within the classes differ, so does the number of zones within the various classes. To give an idea of the variety of rate fixing methods according to class of commodities, special attention is drawn to the system of the U. S. A. railroads, which is characterized by a particularly high degree of differentiation. The railroads of the A. A. R. distinguish between two categories of rates, i. e. class rates and commodity rates. In the railroads' Uniform Classification generally applying in the area east of the Rocky Mountains (except on trans - continental traffic), commodities are assigned to 31 classes. The Consolidated Classification, which applies in trans-continental traffic, Inter-Mountain traffic and in the areas west of the Rocky Mountains comprises twelve numbered classes, five lettered classes with eight multiple classes. The class rates are based on a distance scale, whereas the commodity rates usually are on a point-to-point or group-to-group basis. These rates are fixed in respect of commercial competition as well as competition between carriers rather than in respect of the distance. The commodity rates have a very wide range of application, generally comprising products of mines, products of forests, products of agriculture, also most of the finished products in wagon- loads.

Prime costs, as a rule, is not considered except in the case of individual exceptional tariffs granted for competitive reasons which, however, reflect the direct costs only. It is evident from the replies received that the majority of railways seek to cover their overall expenses by combining the revenues from both freight and passenger traffic. The exceptions are, as already pointed out, certain railroads of the A. A. R., whose obligation to quote « just and reasonable » rates presupposes an accurate knowledge of prime cost. Standard rates are not determined on the basis of the costs of the individual traffics. A peculiarity worth mentioning is the fact that the Japanese National Railways determine their rates for their 15 wagon load classes in such a way that the revenue from the total traffic of all classes, if charged at the rate of the lowest class, covers the direct operating expenses. The New South Wales Government Railways assess their freight charges by ascertaining the cost of haulage for the past twelve months and by adding a reasonable margin of profit plus a further margin to cover losses for traffic carried at non-paying rates.

The fixation of special rates is regarded as the essential means to ensure for the railways a proper share in the economic progress of the country under the following two aspects. On the one hand, the purpose of special rates is to foster the development of certain branches of trade and industry and, thus, the general prosperity of the country and in turn benefit from the enhanced volume of traffic offering. On the other hand, the special rates are granted with the object in view of checking competition of other carriers in order to gain new or retain

existing business. Considerable efforts to win new traffic are being made everywhere and to this end the railways are in constant close touch with trade and industry. In some cases current adjustments of tariffs to the rising costs may serve as a suitable means to permit the railways to share in the increased national income.

Special tariffs, however, have been imposed upon some railways for political reasons for which no compensation is granted by the government and which consequently have adverse repercussions on the earnings of these undertakings. The purpose of these tariffs is to keep the prices of certain raw materials for certain branches of trade or certain districts or of essential goods for daily necessities at a low level. This, in particular, applies to the German Federal Railway and the Japanese National Railways, whose losses in revenue from these mandatory tariffs amount to about 1.5 and 3.3 % respectively of the total revenue.

IV

The competitive situation of the Railways in regard to tariffs.

1) Before discussing the tariff problems of the railways in comparison with those of the other carriers, it will be useful to study the *general legal relations* of the various carriers to the State.

The vast majority of *railways* are owned by the State. The National railways are either under the direct management of a governmental authority (ministry or railway department of a ministry), as for instance the State Railways of Norway, New South Wales, Ceylon, Egypt and Iraq; or they form a separate railway board, which has either the character of a government agency (e. g. in Sweden and New Zealand) or constitutes an intrinsically autonomous concern (Burma Railways). The status of pure institutions of public law has been conferred to the Japanese and Tasmania Government Railways. In some exceptional cases the National railways are combined with certain highway and water carriers in a common government agency, as in the case of the British and Irish Railways.

Besides the National railways there are also privately owned railways in practically all countries. Their relationship to the State in regard to tariffs is not fundamentally different from that of the State owned railways.

The *highway, inland water* and *air* transport services are, with few exceptions, operated by private undertakings. Air transport is nationalised in Iraq, Burma and Ceylon. Highway and inland water transport is in most countries subjected to a more or less rigid regulation. Such regulation appears, generally speaking, less severe in the case of inland water than in the case of road transport. There is, however, a variety of differences, as will be shown in the second part of the next chapter.

2) A fundamental obligation imposed on the railways is, and has always been, the obligation to carry. It is only in conjunction with this obligation that the various other obligations of the railways in regard to the establishment, public filing and application of tariffs gain special importance. As to the material principles governing the establishment of tariffs, an accurate picture cannot be gained from the answers furnished by the various railway administrations. It is not clearly discernible how the obligation to safeguard the interests of national economy is delimited against the commercial requirement of securing adequate revenues. This is, in fact, an extremely difficult problem, which is further complicated by competitive considerations. But a certain distinction could be made according to a criterion already mentioned, viz. the imposition or non-imposition by the government of a mandatory obligation to grant certain tariffs in support of

certain branches of trade and industry, or certain social tariffs, without adequate compensation. The aspect of national economy predominates with those railways who are under such mandatory obligations, as opposed to other railways who lay greater stress on cost factors or other considerations. Here again, the railways of the A. A. R. form an exception, in that competition between them has from the outset been regulated by Government authority. Formally, the rates and charges of most railways are subject to authorisation by government agencies, in some case even by Parliament (e. g. in Norway, Japan, Ceylon). In Great Britain the tariffs must be submitted to a special Transport Tribunal. As far as the Irish, East African, Iraqi and New Zealand Railways are concerned, it appears that no special authorisation is required for the rates and charges established by the competent railway board. The obligation to publish the rates is imposed on practically all railways. Most of them publish their tariffs after they have been authorised, while in the case of the A. A. R. railroads the publication and authorisation procedures are combined with each other. The tariffs to be published by the American railroads do not become effective until it has been ascertained that no objection are raised by competing carriers, by the Interstate Commerce Commission or by State Commissions. In the event of protests an investigation of the reasonableness or unreasonableness of the charges is made in the form of a hearing.

As far as the application of tariffs is concerned, the majority of railroad administrations have adopted the principle of fixed rates, while others have established maximum and minimum rates. Applying fixed rates generally means applying equal rates, while the principle of maximum and minimum rates leaves room for special agreements with individual customers which need not be published. But a rigid distinction cannot be made. Thus, the Burma and Indian State Railways, though applying the system of maximum and minimum rates, do not permit the application of unpublished reduced rates. The British Transport Act of 1953 authorises the British Railways to grant reductions justified by competitive conditions without having to publish them. Similar agreements with individual customers appear to be possible in Sweden, Egypt and Tasmania.

As regards the *other carriers,* their greatest advantage over the railways lies in their general exemption from the obligation to carry and in the freedom of choice of the lines to be served and the kind of traffic to be carried. Their tariffs are generally established on private business principles. However, an increasing control and inclusion of these carriers in a control system is noticeable, depending on the degree of development of trade and industry and on the traffic requirements of the respective country. It seems that private road traffic is practically free in all countries. An important exception to the general rule is Great Britain, where both road and inland water haulage is exempt from any tariff regulations whatsoever. Only the regular bus lines and I W T passenger services are subject to certain price regulations.

The various control systems mostly stipulate that tariffs must be published and authorised by a government agency. Authorisation by Parliament does not appear to be required anywhere. A certain system of fixed rates is only applied in Norway, Japan, in the A. A. R. territory and in the Federal Republic of Germany, while maximum rates are more or less strictly adhered to in all other countries. A brief outline of the peculiar conditions prevailing in the Federal Republic of Germany, in the U. S. A. and in Ireland may be of interest.

In *Ireland,* the governmental transport agency (The Board) entertains both inland water and road transport services. As I W T carrier the Board has the same obligations in regard tc the publication

and application of tariffs as in its capacity of rail carrier. Certain inland water services are operated by private bye-traders, who have complete freedom of action, being responsible only for the payment of appropriate tolls. The operation of road passenger services is subject to licensing and publishing of fares in the form of maximum rates. Professional road haulage outside the exempted area of certain ports may only be operated under an appropriate licence, but no tariff regulations are imposed on such licenced carriers. The Board itself has an unlimited licence to carry freight for reward and does in fact operate a large number of road haulage services. The Board is also the greatest omnibus operator of the country. In both instances the Board has freedom of action regarding tariffs, subject to the general obligation to avoid undue preferences.

In the area of the *Federal Republic of Germany* professional road passenger services are subject to a certain amount of regulation, as far as the establishment and publication of fares is concerned. Bus fares are established in the form of fixed rates. As to the provisions governing professional freight haulage by road, a distinction is made between short distance and long distance traffic. While maximum rates apply in short distance haulage (operated within a radius of 50 km from the home station of the vehicle), fixed rates apply in long distance traffic, which are materially identical with those applied in haulage by rail (principle of tariff parity). As far as freight haulage on inland waterways in concerned, fixed rates apply for traffic within Germany, while agreed charges are applied in traffic with foreign countries, the latter playing a particularly important role on the Rhine.

The highest degree of differentiation seems to be attained in the U. S. A., where a distinction is made, in freight traffic, between common carriers (with motor common carriers as sub-category), contract carriers, private carriers and exempt carriers. Common carriers are operators of general public traffic by rail, inland water and highway. The motor common carriers and the common carriers by water (including Great Lakes and coastal shipping) are less severely regulated than the common carriers by rail. Freight rates other than those exempted from regulation must be fair and reasonable, they are liable to protestation on the part of competing carriers or the I. C. C., and they must be published, filed and adhered to as fixed rates. The common carriers by rail are prejudiced by the provision of Section 4 of the Interstate Commerce Act prohibiting the railways from charging a lesser amount to a more distant point or a higher rate to an intermediate point without prior application to and autorisation by the Interstate Commerce Commission, and this regardless of the fact that motor or water carrier competition may exist to the further point and not to the intermediate point. Moreover, prior relief must likewise be obtained from the Commission unless the railroads permit the lower rate to the more distant point to be used in combination to construct lower through rates from and to widespread origins and destinations.

Motor carriers are not subject to these provisions, and the application of such provisions to water carriers is practically meaningless because they serve only the larger points. Common carriers by inland waterways are further privileged by the fact that transportation of domestic bulk commodities such as grain, coal, ore, sand, gravel, crude petroleum, gasoline and sulphur is exempt from regulation.

Contract and private carriage is restricted to the field of road and inland water transport, while exempt carriers operate road services only. Contract carriers are operators engaged in transportation of freight for certain industrial enterprises at agreed charges under contractual arrangements. They are only held to file their minimum rates, which need not be published. Private carriers, who operate

transports for own account, are, like in all other countries, completely free from regulation. Exempt carriers engaged in the truckage of livestock, fish, agricultural and horticultural commodities are likewise exempt from regulation. As regards the passenger bus companies operating in the U. S. A., their fares are also subject to certain government control prescriptions.

Apart from the lack of uniform regulation, the railways are prejudiced by the restrictions on their freedom of action, in particular the difficulties encountered when intending to abandon unprofitable services or when trying to employ other modes of transport. Similar difficulties are also encountered in other countries.

3) The handicaps imposed on the railways in competition with other carriers are in some countries counterbalanced by certain government contributions (e. g. reimbursement of operating deficits, compensation for certain public service performances, payment of certain pension and salary expenses, grant of other subsidies). This appears to be logical in the case of those railways whose budget forms an integral part of the general State budget. The Swedish State Railways, the National Railways of New South Wales, Tasmania and Iraq are entitled to reimbursement of eventual operating deficits. In Ireland the annual service of loans is legally guaranteed by the State. The State Railways of Burma and New South Wales are granted subsidies for the maintenance of unprofitable services, and the Japanese National Railways are entitled to Government contributions to pension expenses for those employees who were already in railway services in 1949 when the railways were an institution of public law.

The balance figures furnished by the questioned railway administrations for one of the past years which, from the viewpoint of transport economy, can be regarded as a normal year, are generally better than had been expected. The figures refer, in the majority of cases, to a year after 1950. When comparing these figures, certain reserves must be made, for it seems that the data furnished are not directly comparable. Nor is it always clearly discernible if they cover all items or comprise operating receipts and expenses only. The balance shows a deficit in the case of the German Federal, Norwegian, Irish, Tasmanian, Ceylon and New Zealand Railways. It must be pointed out, however, that it would have been more appropriate, at least in the case of the Federal Republic of Germany, to refer to a year prior to World War II, because the subsequent years can hardly be regarded as normal from the viewpoint of transport economy, considering the extensive war damage to railway installations and rolling stock as well as other factors. In the case of all other railways the balance shows a surplus, or accounts balance.

Only few answers reveal how expenses are split up between passenger and freight traffic and to which of these services the deficit is attributable. Most railways refrain, or are prevented by their accounting system, from separating expenses between passenger and freight.

It is only in Sweden and India that the expenses chargeable to passenger and freight service respectively are covered by the respective revenues. This seems also to be the case with the Iraqi Railways, while it is doubtful whether the same can be said of the East African Railways. The Japanese National Railways register, on the basis of a rough estimate, a profit of 2 % in passenger and a loss of 3 % in freight traffic for the business year 1953. The operating revenues and expenses of the Class I railroads of the A. A. R. for the period from 1939 to 1953, excepting the years 1942-1945, show a deficit in passenger services. As far as the German Federal Railway is concerned, the surplus from fast passenger train operations is more than absorbed by the deficit in ordinary passenger train services caused

by the low rates offered to workers and students.

4) The figures for the *traffic performances* of the railways in comparison with those of the competing carriers are a true mirror of the unequal conditions regarding tariffs. A clear distinction can be made between the railways of those countries whose trade and industry is fully developed, and the railways of less developed countries.

In the case of the former group, the ratio of *passenger traffic by rail* to the total volume of passenger traffic in the respective country is relatively low and shows a marked downward trend. Thus, in the area of the Federal Republic of Germany, the total volume of traffic has greatly increased between 1936 (index 100) and 1954 (index 245), whereas the share of rail traffic has declined from 100 to 72 during the same period. The winners are road and air transport. Air, the latest of the fully developed carriers, shows the highest relative increase, while it lags behind road transport in terms of absolute figures. Most significant is the development in the U. S. A., where the share of rail in intercity passenger traffic has fallen from 65 to 48 % between 1939 and 1952 and continues to show a downward tendency. The share of bus traffic has risen from 26 to 34 % between 1936 and 1950 but has fallen since then, while the share of air transport shows a considerable and steady increase (from 2 to 18 % between 1939 and 1952).

The other group of railways are characterized by a considerable increase in the ratio of rail to total passenger traffic. This increase amounts to 9 % between 1936 and 1953 for the Japanese National Railways, 54 % between 1936 and 1953 for the Railways of New South Wales, and 18 % between 1946 and 1954 for the East African Railways.

Conditions are somewhat different in the field of *freight service*, where the ratio of rail to total traffic is higher than in the case of passenger service, and the relative share of air transport is almost insignificant. Thus, the ratio figures indicated by the British Railways and the Swedish State Railways are 60 % for 1951 and 51 % for 1950 respectively. In the United States the share of rail service in the total volume of freight traffic has declined from 63 to 55 % between 1939 and 1952, against an increase of truck transportation from 10 and 16 and pipeline traffic from 10 to 14 %. The proportional share of the two latter modes of transport continues to rise. Also the Japanese National Railways have recorded a decline in the rail freight ratio (from 35 to 27 % between 1936 and 1953), while the New South Wales and East African Railways report a relative increase of rail traffic by 38 % and more than 100 % respectively.

In the light of these figures it appears logical that the increase in transport *capacity* is many times greater in the case of motor and other competing carriers than in the case of the railways, particularly in the countries of group I. In this connection it is necessary to consider not only the increase in the number of road vehicles but also the acceleration of the turnround, which results in an increase of capacity. Developments are not always identical in passenger and freight traffic. Thus, road transport capacity in Japan has remained stationary in passenger service but has trebled in freight service between 1935 and 1953.

5) In view of the increasing volume of motorized traffic it is only natural that the railways should participate, or endeavour to participate, in such transport either directly or indirectly. The railways can be prompted to do so by manifold considerations. The desire to support the general effort towards rationalisation of rail operations (by supplementing or replacing existing railway services), to provide better service for the customers, and to screen rail traffic from competition

are some of the major reasons for such participation. Most of these participations concern road and inland water transport, while air transport is only involved in some instances. Apart from those cases where different modes of transport are combined under one authority, which applies in particular to Great Britain, Ireland and East Africa, we may distinguish between two groups, viz. (1) railways with more or less extensive participation in other means of transport, and (2) railways with negligible or no such participation at all. The German Federal Railway and the State Railways of Sweden, Japan, India, New Zealand and Ceylon may be classed in the first of these two groups. A peculiar feature of the Indian system is the existence of joint road undertakings in which both the Government and the Railways (in some cases also individual private enterprises) participate. The second group comprises the Norwegian State Railways and the railroads of the United States, whereas the remaining railways are not engaged in any other modes of transportation. The road and water transport services operated by the railways are in all countries governed by the general provisions applicable to these services.

6) In order to strengthen the competitive situation of the railways by cost reductions and lower rates, a number of measures could be taken, such as :

a) rationalisation of rail operation by improvements in equipment and organisation;

b) relief from expenses which do not concern transportation proper.

Practically all railways believe that rates could be reduced by rationalising rail operations. In this connection particular importance is attached in Europe to cost reductions by increased technical standardization. Some railways confine these measures to an improvement of their equipment (modernisation etc.); they are apparently convinced of having attained their optimum form of organisation. The Japanese National Railways indicate that any savings attainable by rationalisation would have to be used first of all to carry out urgent improvement and renovation works, and that they would not be able to reduce their tariff level within a measurable space of time. Against this we may quote the opinion of the East African Railways, who point out that continued improvements in operating efficiency and internal organisation have not only allowed greatly increased volumes of traffic to be dealt with but have also enabled the Administration to maintain tariffs which are only some 35 % above the prewar level despite the high general level of prices.

As regards the items of expenditure which do not concern transportation proper, these imply all those Government measures which are detrimental to the railways. They include, in the first place, the mandatory obligations imposed on certain railways for political or economic reasons without due compensation. Another important factor prejudicial to the railways is the government policy of paying or contributing to the roadway cost of competing carriers. Such measures are bound to influence the general level of railway tariffs. The abolishment of these Government measures will have a varying effect on the tariff level depending on the extent of the prejudice caused to the railways.

7) The other carriers are, in practically all countries, exempt from mandatory obligations for public service. As an exception to this rule we may mention the Government tax levied in New South Wales for intrastate road transports competing with the railways for distances exceeding 50 miles.

As far as the cost of roadway is concerned, Sweden seems to be the only country in which current revenue from motor vehicle taxes covers all such expenditure on highways as is referable to motor-

ized traffic. In all other countries it is the tax-payer who more or less contributes to the expenditure for the building and upkeep of highways, inland waterways, port facilities, airports, etc.

V

Existing principles of coordination. Effect of competition on the tariff system of the Railways.

As will be gathered from the foregoing observations, the existing principles of coordination between the various modes of transport are far from being uniform. In some countries there is no coordination at all. It should be noted, however, that the question of coordination is less imperative for countries with poorly developed trade and industry, as long as the demand for transport exceeds the supply. Where coordination exists, sea transport is entirely and air transport almost entirely excluded. Even inland water transport is only partly comprised in the coordination programs. Where inland water and rail services are combined under one management, competition can be regulated in a harmonious way. However, where the railways are up against an important and independent I. W. T. industry, as in the case of the United States and the Federal Republic of Germany, the problem of coordination is more difficult. The railways of these two countries are handicapped in their competition against water transport by the imposition of minimum rates for volume movements or of certain specific rate-making principles to which the railways must adhere.

The greatest diversities obtain in the field of competition between Rail and Road. Apart from those countries where no road competition exists (e. g. post-war Burma), there are countries whose coordination policy embraces passenger rather than freight service, and vice-versa. While freight services are not coordinated in Great Britain, these services are the chief object of coordination in the United States. In India cut throat competition is precluded by a well balanced system of obligations imposed on the various carriers. The highest grade of coordination seems to be attained in the passenger services of the London area by providing the greatest possible degree of assimilation between bus and rail fares. Where passenger road services are subject to licensing, an investigation is generally made into the necessity of such services, having due regard to the interests of the railway. In practice, however, road competition against rail has not always been checked by these licensing procedures; this applies, for instance, to the passenger services of Great Britain outside the London area and to the passenger and freight services of the Federal Republic of Germany.

The most conspicuous feature in road transport is the almost unrestricted development of private traffic in all countries. In the face of this development the licensing procedures to which the professional road carriers are subjected lose in importance. Coordination of professional freight transport centers on long distance haulage, although there are some countries (e. g. Japan and Tasmania) which seem to place greater emphasis on the licensing of short distance hauls. The Federal Republic of Germany has tried to regulate competition for long distance freight by setting, right from the start, a fixed limit to the number of licences to be issued. In spite of some improvements brought about by this measure, the overall pressure of competition on the railways has not materially abated, which is chiefly due to the unhampered development of private traffic.

It appears that transport competition continues to increase in all countries, which is not surprising considering the increased importance of the motor vehicle as an individual (and largely subsidized) means of transport.

Apart from the influence which inland water transport policy has exercised on railway freight rates in some countries, it appears that road competition alone has materially affected the entire tariff system of the railways. In this respect several stages of development are noticeable, particularly in freight traffic. Broadly speaking, it can be said that in many countries, both in passenger and in freight traffic, such tariff increases as would have been necessary in view of the general level of prices could not be carried into effect because road competition had to be taken into account. Alternative solutions have been sought in the form of individual measures of various kinds, both in passenger and in freight traffic. Some railways have also tried to relieve the pressure of competition to which they were exposed by acquiring passenger and freight transport undertakings. Efforts towards a new rate-making policy by reassessing the various cost factors are only noticeable in the field of freight traffic. The most extensive step in this direction, implying a radical departure from customary rate-making principles, is the abolishment of the system of fixed rates and the substitution of a system of maximum rates, as it has been adopted in Great Britain. Other railways have confined themselves to mitigate the « ad valorem » rate-making principle by compressing the taper scales, either by abolishing some of the higher classes (e. g. New Zealand) or by reducing the rates of the higher and raising the rates for the lower classes, thus altering the span between the various classes (e. g. German Federal Railway, Swedish State Railways). The tendency to depart from the « ad valorem » principle of rate-making has lead to an increased consideration of the quantity factor in the tapering system and, in some cases, to a greater increase of the rates for shorter distances in comparison with those for longer distances, or to a greater increase of partload rates as against carload rates.

VI

Wishes for a future regulation of competition between the various carriers.

Function of the tariffs in connection with the coordination of carriers.

Only very few railways have in their replies made a clear distinction between passenger and freight traffic. A number of railways outside Europe and America have stated that there is no or little need for any alteration of their present basic tariff structure. Thus in India the present regulation of road transport is considered adequate. The Tasmanian Railways hold the view that due to the topographical conditions of their country and the fact that their industries are situated almost exclusively in the coastal areas and there is little traffic in the mountain districts, a modification of their present system is impossible. Also the New Zealand Railways deem an alteration of their rates structure at the present stage of development of their country inexpedient and the protection of the railways against road transport by compulsory licensing procedures is regarded as adequate. In Burma the danger of competition from road transport has greatly diminished since the nationalization of railways, Indian Waterways and Air transport and the revision of the tariff system after the recent war. Should such competition revive, a coordination by mandatory control or by nationalization is considered necessary by this country. East Africa, too, intends to retain the basic structure of its differential tariffs and believes to be able to meet increased competition by lessening the range of charges. Similarly, the Iraqi State Railways contemplate no departure from their present tariff policy. They are confident that the low level of their rates will attract sufficient traffic for their railways for quite some time to come and that their government will make the necessary

adjustments should in the course of the further economic progress of their country the supply of transport overtake demand.

Those of the above railways who advocate that the railways, too, conduct their business on commercial principles naturally make strong reserves which are almost tantamount to a decline. The least they demand is that in the case of commercial management adequate services must be maintained for the benefit of their country. Some of them also point out that, logically, private road transport is not in a position to fulfill mandatory obligations to the same extent as the railways, in particular to bear the cost for the maintenance of existing, let alone the construction of new roads. To sum up, the present system of railway tariffs with its burden and regulations is considered necessary and the present measures of bridling competition by a system of strict licensing in the interest of the further economic development of their countries are deemed adequate.

On the other hand, there exists a group of railways who more or less pronouncedly advocate the departure from the existing principles of coordination and an alteration of their tariff structure. In these countries the former de facto monopoly has been replaced by a system of traffic competition. The railways of these countries demand that they be given the possibility of conducting their affairs as though they were a commercial enterprise. They point out that this can be achieved in different ways, for instance by fixing the rates on the basis of the actual prime cost so that the traffic falls to the carrier who is the cheapest from the national economic point of view. In this connection there is a general tendency to essentially reduce the expenses by long-term programs of rationalisation and modernisation, notably by switching from steam to Diesel-electric and Diesel traction. The most obvious consequence of the new system of traffic competiton, as far as rate-making is concerned, is the abolishment of the principle of equal rates for all parts of the network, the replacement of fixed rates by a flexible system of maximum or agreed charges and a strong diminution of social tariffs in passenger traffic. Other corresponding measures are restrictions in branch line operations as well as the obligation imposed on the competing carriers (road, water and air) to bear their due share of the expenses incurred in the construction, maintenance and protection of their roads.

The greatest progress in this direction has no doubt been made in Great Britain where after approval by the Transport Tribunal under the Transport Acts of 1947 and 1953 a new Charges Scheme will come into force, the avowed object of which is the adoption of strictly commercial principles and the creation of a new structure of railway freight charges. The classificatioin of commodities according to value has been abandoned. The rates will be maximum rates within which the British Transport Commission will be free to determine the individual rates on commercial considerations. As hitherto, freight rates for transports by road are not controlled so that free competition can take full effect. Rates are calculated on the basis of prime cost, having regard to weight, loadability, volume and regularity as well as the volume of traffic over the particular route. It must be stressed that there seems to be no apprehension on the part of the Transport Commission that the application of the new system will lead to unsatisfactory transport services in certain regions, since the Scheme provides for the possibility of quoting reasonable fixed charges in individual cases and for appealing to the Transport Tribunal in case of dispute as before. In the passenger traffic field, too, there evidently is a tendency of quoting fares which more strictly reflect the prime cost and take into account competitive conditions. In connection with this revision of tariff policy mention should be made of Great Britain's large

scale program of modernisation, which in particular includes the electrification of the entire network.

Probably the nearest approach to the stage of development in Great Britain is made by the U. S. A. and Swedish railways. In both countries, however, road traffic is still subjected to licensing and control procedures. The railways of the A. A. R. in particular demand the abolishment of the discriminating regulatory laws for the various carriers and a restriction of the issue of operating licences to contract carriers and exempt carriers, a certain control being exercised to make sure that these carriers only serve the shippers indicated in the licence. They insist on increased reliance on competitive forces in rate making and greater emphasis on considerations of competition after appropriate measures have been taken to ensure that essentially the same mandatory obligations are imposed on all carriers. They further demand that no insurmountable obstacles are placed in the way of discontinuing unprofitable services and that they be granted equal opportunity to use other means of transport.

The Swedish railways, too, demand the adapting of their tariff policy to the new system of competition, a relaxation of the principle of « consistency in space » and « consistency in time », consideration of the prime cost factor by granting quantity rebates to customers tendering traffic in several wagon loads or within a certain space of time. Though these railways do not consider it practicable to conduct the affairs of their undertaking on a strictly commercial basis, a tendency in this direction seems to be prevalent. A Government Committee set up to study traffic problems is at present working out the main principles of a new national traffic policy aiming at a rational use and a coordination of the existing means of transport.

To an even greater extent the German Federal Railway, the Norwegian and the Japanese National Railways are looking for alternative solutions which constitute a compromise without involving too radical fundamental changes. Though these railways also object against mandatory obligations being solely imposed on the railways which in turn are bound to result in further deficits and an increased need for Government subsidies, there appears to be a certain hesitation on their part to lay greater stress on considerations of prime cost in their tariff structure and to abandon the « ad valorem » principle in order not to jeopardize the public utility character of their transport services. The Japanese National Railways also emphasize the fact that in their country they are obliged to continue the operation of non-paying lines in the public interest. Starting from a consistent cost reducing policy, a mixed system therefore is sought by combining the necessity of competition with the principle of rate-making according to the value of goods. Similarly, the German Federal Railway considers it necessary, as far as their passenger traffic is concerned, to reduce the excessive application of social tariffs, to simplify the structure of fares with the object in view of lowering also the ordinary fares and to make appropriate cost adjustments within the passenger traffic. In all three countries the railways insist on a definite restriction of the traffic of the competing carriers as well as the regulation of their tariffs. In view of the fact that door to door transports of freight by road constitute a more complete service than rail transports from station to station, efforts are being made in the Federal Republic of Germany towards the application of higher rates for road than for rail transports. It should be mentioned that the Japanese National Railways consider it possible to raise the level of their tariffs without the risk of losing part of their freight or passenger business. Broadly speaking, developments are still in full swing.

Other railways, too, are searching for new forms of coordination and in conjunc-

tion therewith for new tariff structures, as can be gathered from the replies received. The demand is made time and again that tariffs should more strictly reflect the actual prime cost, that equal mandatory obligations should be imposed on all carriers or, where this proves impossible, that competing carriers including private traffic should be subjected to a more rigid control.

The information furnished gives no clue as to whether and to what extent the railways are in a position to materialize the measures deemed necessary by them.

It is to be presumed that on account of the strong conflicting interests considerable resistance is met everywhere.

VII

Conclusions.

The following conclusions can be drawn from the foregoing analysis :

— A vigorous economic, cultural and social development is noticeable in all countries.

— This development has brought about a considerable increase in the volume of traffic.

— The railways, being aware of their duties towards national economy, are striving to effectively foster this development by adopting a rate-making policy with due regard to the special conditions of their country and to render the greatest possible contribution to satisfy the transport requirements of the nation.

— In countries whose transport system is not yet fully developed the share of the railways in the total volume of traffic is relatively high.

— In the other countries the efforts of the railways have been hampered by a development which, in conjunction with the rapid expansion of trade and industry and the resulting increase of the traffic volume, has led to an excessive supply of transport on the part of carriers who are more or less free from mandatory obligations.

— The railways of those countries whose transport system is not fully developed will benefit by this experience and will carefully watch the development in their own country in order to be able to take appropriate measures in good time to ensure the retention of their business.

— Those railways who have been handicapped in their efforts to get their fair share of the traffic of their country will endeavour to achieve the following principal aims;

— modernisation of their railway system with resulting reduction of cost;

— relaxation of Government regulations imposed on the railways, in particular with regard to tariffs;

— widest possible adjusment of burdens between the railways and the other carriers;

— compensation by the Government for special services rendered by the railways in their capacity of public transport undertakings.

[656 .254 (493)]

The modernisation of train control installations on the Belgian Railways,

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INTRODUCTION

Many European Railway systems and nearly all North American systems make use of train-dispatching installations to control the movements of their trains. Although the use made of such installations may vary considerably as between one system and another — not only because of differences in track layout and train composition but also, and this is perhaps the more potent reason, because of different operating conceptions — the technical installations may nevertheless be almost identical on different systems and have in fact been so until a short time ago.

In recent years, however, modernisations of equipment and circuits have been introduced on the French [1] (*), British [2] and Belgian systems. The Canadian Railways have improved their dispatching circuits [3]. The present communications is designed to describe the modernisation which is at present being carried out on the network of the Belgian National Railway Company (S.N. C.B.).

(*) The figures in brackets refer to the bibliography at the end of the article.

The Belgian Railways employ « Western Electric » selectors [4] [5] using the well-known 17 impulse code. This selection system has been preserved. The improvements carried out on the Belgian Railways were mainly concerned with the telephone transmission and the control room equipment; they were introduced on the occasion of the electrification of the most important sections of the system.

With the electrification of the system (using 3 000 Volt D.C. supplied by mercury-arc rectifiers), it became imperative to put the control circuits into underground cables. It is not possible to apply to the cables the two-wire overhead technique because of the many times greater attenuation, per kilometre, of the cable circuits, even if these are coil loaded (*). It therefore became necessary to carry out further research on circuits, taking into account the fact that, in certain cases, sections of overhead lines are still alternating with cable sections. This research work is discussed in Part I below.

(*) Cables where the transmission attenuation is reduced by coil loading (procédé Pupin), i.e. where the inductance is increased by the provision of regularly spaced coils.

Together with the improvement of the transmission system, improvements were carried out which were designed to facilitate the operation of the control desks by using loudspeaker-type telephones (without conversation treadle) and keyboards for the selection of the telephone station required, at the rate of one key per station. At the same time, supplementary facilities were introduced in the remaining telephone system. These works which also include the acoustic treatment of the walls of the control room premises, are described in Part II.

Finally, some examples of circuits and actual installations are given in Part III.

PART I.

IMPROVING THE TRANSMISSION PERFORMANCE OF THE CONTROL CIRCUITS.

1. General.

Whilst in ordinary telephony, communication is established between two persons at the ends of the line, it may happen in control circuits that a great number of telephones are connected to the same line. This feature entails transmission problems concerning the talking and ringing currents, requiring technical solutions which may differ as between one installation and another according to the type of line and the operating routine of the system. But all these problems have a common theoretical basis which we shall study, by way of introduction, in paragraphs 2 to 5. These theoretical considerations are subsequently applied to the different solutions adopted in Belgium, and an attempt is made to justify the choice of these solutions (paragraphs 6 to 8). There follow descriptions of the 2-wire, 4-wire and 2-frequency-bands system (paragraphs 9 to 11). Details of certain calculations have been relegated to the Appendices.

2. Optimum impedance of way stations.

In the case of a line of negligible length, the power of a transmitter (the microphone of a telephone post) of internal impedance R is best divided between a number of n receivers if each of the latter has an impedance nR so that the load constituted by all the receivers in parallel connection is adapted to the source. Each receiver thus receives one fraction $1/n$ of the energy, and the attenuation due to the presence of these n receivers amounts to :

$$A = \frac{1}{2} \log_e n \text{ Nepers } (*) \qquad (1)$$

If the transmission takes place on a line with the characteristic impedance W, the attenuation will at least have the value given by equation (*). But for a long line, the determination of the optimum impedances in respect of the line, the transmitter and the receivers is less straight-forward. The problem has been studied by several authors [1] [5] in

(*) It is well-known that, in telephony, attenuations (and gains) are expressed, not e.g. in percent, but in units of Napier's (or decimal) logarithms, « Nepers » or « decibels » : If N_1 and N_2 are the energies to be compared, the attenuation (or gain) of N_2 in relation to N_1 is expressed by :

$$A = \frac{1}{2} \log_e \frac{N_1}{N_2} \text{ Nepers}$$

or

$$A = 10 \log \frac{N_1}{N_2} \text{ decibels.}$$

relation to certain specific cases. We believe, however, that the considerations that follow bring out the essential points more clearly. To begin with, it may be pointed out that the existence of an optimum value of the impedance R of the way stations is evident, seeing that receivers well adapted to the line would constitute an inadmissible shunt loss for the following receivers, whilst receivers with very high internal impedance would receive very little energy. It is also physically evident that the best compromise consists in using receivers with an impedance which decreases with the distance from the transmitter. A very approximate calculation, contained in Appendix A, shows however that the reduction of the attenuation effect compared with the case of uniform impedance is of little significance. Moreover, a variation of the impedance (except by a small number of intermittent steps) is hardly practical.

The theoretical study of the transmission conditions on a control circuit, based on the actual distribution of the way station is obviously impracticable. The approximative calculations contained in Appendix A are based on the following simplifying assumptions :

a) the n receivers with a comparatively high impedance R of the pure resistance type, distributed over a distance D (kilometres), are regarded as a loss uniformly distributed along the line :

$$g = n/\mathrm{RD} \quad \text{mhos/km} \qquad (2)$$

b) the attenuation along the line is calculated on the basis of the approximation formula well-known in telephonic transmission over coil loaded cables :

$$\alpha = \frac{r}{2}\sqrt{\frac{c}{l}} + \frac{g}{2}\sqrt{\frac{l}{c}} = \frac{r}{2\mathrm{W}} + \frac{g\mathrm{W}}{2} \qquad (3)$$

If the line works between the characteristic impedances W at the two ends, the attenuation from the transmitter to the last way station receiver consists of the line attenuation α D and the attenuation due to lack of adjustment between W and the impedance R of the posts. This total attenuation becomes a minimum if :

$$\mathrm{R} = n\mathrm{W} \qquad (4)$$

and amounts to :

$$\mathrm{A} = \mathrm{A}_o + 0.5 + \frac{1}{2}\log_e n \text{ Nepers} \qquad (5)$$

where A_0 is the attenuation of the line itself, without shunted circuits. The term 0.5 N arises from the distributed loss. The impedance optimum is not critical. Halving or doubling the impedance for all the stations will increase the value of (5) by no more than 0.07 N. In practice, the number n is always of the order of several dozens, giving rise to high values for R.

Equation (5) can only be applied to a line which is terminated, at the far end, by an artificial load (resistance) equal to its characteristic impedance. This is indispensable in the case of coil loaded cables in order to avoid the appearance of stationary waves which would be produced by the return of a part of the energy owing to reflection on the artificial load. If there is, for instance, a propagation speed of 20 000 km/sec., the wave length at the frequency of 2 Kc/s is 10 km, and a potential node would arise at the distance corresponding to a quarter of the wave length (i.e. 2.5 km) from the open end. This phenomenon would

produce a considerable distortion, and certain frequency bands would become practically inaudible at the sets near the end. This does not happen (or at least only to a minor degree) in the case of open line wires which are not coil loaded, since the propagation speed is then much higher. In the case of such an aerial line, there is a gain of 0.35 N compared with equation (5).

3. Attenuation of call voltages.

The theory of the transmission of D.C. or A.C. of very low frequency of a line with call receivers or selectors is set out in Appendix B. Here again, the receivers are regarded as representing a uniform loss (2), where R now signifies the impedance, still assumed to be ohmic, of a receiver at call current frequency. If V_D is the minimum operating voltage of the last receiver and r the resistance per unit of length of the line, the minimum transmission voltage is :

$$V = V_D \operatorname{ch} \sqrt{\frac{rnD}{R}} \qquad (6)$$

In practice, it is desirable not to exceed a given transmission voltage so that equation (6) determines the maximum range of call without repetition.

If one regards as given the minimum energy :

$$P = V_D^2/R \qquad (7)$$

required to operate the last receiver, the transmission voltage becomes a minimum for :

$$R = rnD \qquad (8)$$

and amounts to :

$$V = 1.36 \sqrt{rnDP} \qquad (9)$$

There is thus also an optimum impedance for the call receivers, and equation (9) determines the range under the best conditions. Equations (8) and (9) are based on an approximation which ceases to be correct for very short lines.

4. Shunts on a coil loaded cable.

As the considerations regarding the optimum impedance of the sets has led to the adoption of a high value compared with the characteristic impedance of the circuits of coil loaded cables (of the order of 10 times the latter), the impedance/ frequency characteristic of the whole installation remains very similar to that of the cabled circuit alone, except if the density of the sets entails abnormal situations. This characteristic can therefore, in spite of the connection of the shunt circuits, preserve its previous regularity. It follows that the working of the telephone repeaters remains possible without difficulty, which was hardly the case with the arrangements previously studied (5), always provided that the condition of high relative impedance remains satisfied. The shunt circuit can be connected at any point of the load section. Under these conditions, the adjustment of the repeater circuits will not cause any particular problem.

In the case of a coil loaded cable, approximate account is taken of the increase in attenuation towards the cut-off frequency, by dividing the line attenuation [the two first terms in equation (5)] by the factor :

$$\sqrt{1-(f/f_o)^2}\,.$$

If desired, the formulae developed by Mayer or Pleijel yield closer approxima-

tions. All this still pre-supposes a uniform loss, and an irregular distribution of the sets is reflected in undulations of the attenuation curve which are all the more marked the more closely the theoretical cut-off frequency is approached. It is therefore prudent to choose a higher ratio than in ordinary telephony of the theoretical cut-off and the upper limit of the band used in transmission practice, and to use, for train control purposes, circuits with comparatively light load only.

In practice, more serious irregularities of the attenuation curve are caused by the fact that the stations are seldom connected direct to the cable. The capacitance of the shunt cable is therefore added to that of the main cable and represents and irregularity on the latter. The effect of the inductance irregularities of the load coils is known. These are negligible for inductance differences of percentage order. Similarly, a branch circuit of a length of percentage order of the load coil spacing (i. e. 10 to 20 metres) will not entail an appreciable irregularity of the attenuation. Branch circuits of 50 metres can still be tolerated in exceptional cases, but those of 100 metres length must be excluded. It would be possible to compensate longer branch circuits by modifying the value of the adjacent load coils but this solution is hardly practicable if the same cable contains other circuits. The simplest way of providing for longer branch circuits is to reduce the shunt capacitance introduced by them by inserting a booster transformer (shunt repeater) at the junction point (cf. Fig. 1). If k is the transformer ratio (booster of telephone station in relation to main cable), it is possible to admit branch circuits of a length k^2 greater.

The inductance L_p of the repeaters shunts the main cable and introduces a parasitic effect. A low-frequency cut-off

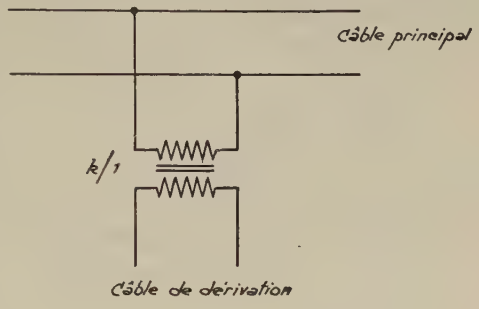


Fig. 1.

Câble principal = main cable. — Câble de dérivation = connection cable.

effect is produced. Again assuming a uniform distribution (cf. Appendix C), this cut-off frequency is found to be :

$$f_o = \frac{1}{2\pi}\sqrt{\frac{n}{DL_pC}} \qquad (10)$$

The resulting correction of the attenuation affects, in a different way, the two first terms of equation (5) which are replaced by :

$$A_o\sqrt{1-\left(\frac{f_o}{f}\right)^2}+\frac{0.5}{\sqrt{1-(f_o/f)^2}} \qquad (11)$$

This expression is obviously incorrect at the cut-off frequency and this side of it. In contrast, the radicals are, for $f > f_o$, real and comprised between O and 1. Towards the low frequencies, the first term (attenuation of the line without stations) becomes smaller because the inductance of the repeaters balances the effect of the distributed capacitance,

whilst the second term (shunt effect) increases. An elementary discussion shows that one or the other effect begins to prevail according to whether A_0 is greater or smaller than 0.5 N. The curve has the shape shown in figure 2A in the former case, and that shown in figure 2B in the latter case.

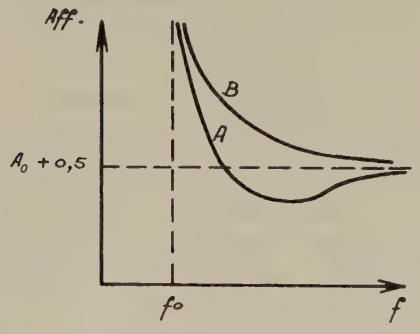


Fig. 2.

Most of the cabled circuits used for train control purposes in Belgium are of the 4-wire type, and the phantom circuit (*) serves for the transmission of the call impulses. The extraction of the phantom circuit to the way stations calls in any case for mid-way contact coils so that it is convenient always to use them as shunt repeaters, and to use way stations with 600 ohm impedance, for talking as well as listening. To avoid the better the effect of the long branch circuits, an uncoupling resistance is series-connected to the secondary side of the repeater (fig. 3). In this way, the shunt effect on the main cable is normally 1 200 k^2 ohm and at least 600 k^2 ohm at high frequencies where the branch cable has a weak input impedance.

Moreover, as the impedance of the main cable, as seen from the branch, is negligible, the uncoupling resistance has the effect of making the branch circuit work between two terminals of 600 ohm. The increase in attenuation due to the series resistance is only 0.35 N. Without the precaution of the series connected uncoupling resistance, the inductance of the station coils would shunt that of the repeaters, and the low-frequency cut-off effect would be inadmissible.

(*) The phantom circuit (or combined circuit) is the one obtained by connecting the mid-points of the repeaters of two real (or component) circuits; in this way, one obtains three circuits with four conductors only.

5. Branch networks.

Branches which are so long that even the repeater does not suffice to reduce to an admissible value the capacitance irregularity created on the main cable must be regarded as independent lines and must, if necessary, be coil loaded in their turn. In that case, the branch must be connected to the main cable by means of a multiple access network which ensures the simultaneous adjustment of the impedances to their rated value.

Branch networks, which have a great practical importance because of the variety of possibilities which they offer in adapting the circuits to the variegated conditions of railway operation, have been studied by a number of authors [3] [6] [7]. They consist either of coils (installation with differential transformer, symmetrical or otherwise), or of pure resistances, or even of a combination of these elements (see Part II, paragraph 9 hereafter). The transmission energy can be distributed in any desired proportions between the main cable and the shunt. If the network

contains resistances, part of the energy is wasted. In practice, the choice of installation will, in each case, depend on the requirements of the diagram of the attenuations tolerated in transmission, and on the cost of the installations.

transmission equivalent between control office and the last station is calculated with the aid of equation (5) and amounts to :

$$E_1 + \alpha D + 0.5 + \frac{1}{2} \log_e n + E_2 \text{ Nepers} \quad (12)$$

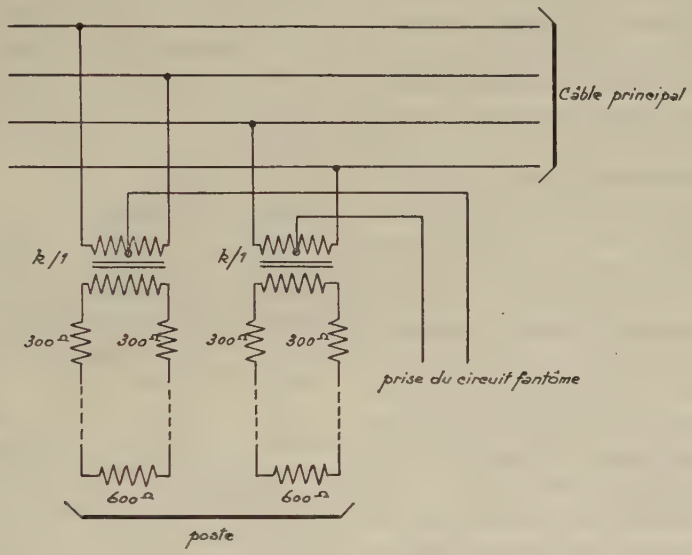


Fig. 3.

Câble principal = main cable. — Poste = station. — Prise du circuit fantôme = intake of phantom circuit.

6. Equivalents (*).

Let us consider the simplest control circuit consisting of an ordinary telephone set at the control office and a single two-wire line (cable or open-wire line) of a length D to which n way stations are shunt connected. If the impedances of the listening stations are best chosen, the

where E_1 is the transmission equivalent of the control office station, E_2 the reception equivalent of the way station and α the attenuation per kilometre of the line itself. The equivalents of the stations are measured against stations adjusted to their rated impedance, and the additional attenuation due to the high reception impedance of the way stations is thus contained, not in E_2, but in the preceding terms.

The equivalent of a microphone (type 2040A) is of the order of 0.6 N (gain in relation to the SFERT standard). If

(*) The equivalent of a transmitter, receiver or complete telephone circuit is the attenuation (or gain) represented by this transmitter, receiver or circuit in relation to standard units of SFERT (Système Fondamental Européen de Référence Téléphonique). The equivalents are expressed in « Nepers or « decibels ».

the combination of microphone and telephone had come about by an ideal symmetric differential, there would be an additional attenuation of 0.4 N. As the induction coil is far from being perfect, this additional attenuation is of the order of 0.6 N, and the total transmission equivalent E_1 of a two-wire station is thus 0. At the reception end, the equivalent of a telephone diaphragm case (type 2684) is of the order of —0.3 N so that one obtains $E_2 = + 0.3$ N. The total of $E_1 + E_2$ is thus no more than 0.3 N, and one will still obtain an excellent quality of communication if the equivalent of the circuit does not exceed 3 N.

We have therefore aimed at a standard of 2.5 N for the major channels, tolerating up to 3 N for secondary branches. In view of the absence of information on this subject in literature, it is difficult to adopt a more precise basis. The only reference which we have been able to find occurs in a report by L.W. East [3], but we are unable to interpret his recommendations because his conventions on the definition of the equivalents seem to differ from ours. Moreover, the outside noise conditions can differ greatly as between one network and another, depending, for example, on the fact whether the way stations are of the indoor or outdoor type. Similar considerations apply to the noise caused in the circuits by high-voltage lines.

With a circuit equivalent of 2.5 N, the range and number of stations connected by a two-wire line without repeaters is determined by the condition :

$$\alpha D + \frac{1}{2} \log_e n < 2 \qquad (13)$$

The equivalent from a way station towards the control office is in practice generally better because the impedance from the way stations to the transmitter can be lower (if a commutation treadle is provided), since there is normally not more than one way station transmitting at any one time. Moreover, an equivalent of the order of 4 to 5 N between two way stations can easily be obtained without other precautions and ensures sufficient audibility to prevent a second way station from breaking into a conversation that is going on.

7. Coil loading.

In order to protect telephone circuits against interference from high-voltage circuits, it is an essential precaution to put the telephone lines running along an electric line into cables. Consequently, it is necessary to resort to coil loading in order to ensure a reasonable quality of transmission, as soon as the length exceeds ten kilometres or so.

The attenuation of a circuit can be reduced either by increasing the section of the conductor, or by giving it a greater load. A well-known calculation thus leads to an optimum coil loading arrangement which reduces the total cost to a minimum, with constant attenuation and cut-off frequency. This has led to the adoption, on the Belgian trunk telephone lines, of a load of 129 mH every 1330 metres, resulting in a theoretical cut-off frequency of 4 kilocycles p. second and a characteristic impedance of 1 600 ohm.

In the case of control circuits, a lighter load is required, firstly in order to reduce the irregularities due to the branch circuits, and secondly in order to derive the greatest possible benefit from loud-speaker listening. But the spacing of 1 330 metres

must be adhered to because of the ordinary telephone circuits using the same cable. The load has been reduced to 75 mH, resulting in a theoretical cut-off frequency of 5.2 kilocycles pr. second and an impedance of 1 200 ohm. The diameters of the conductors have been standardized at 0.8 mm and exceptionally at 1.0 or 1.3 mm for lines of great length or with multiple branches.

The attenuation of 800 cycles of an 0.8 mm two-wire line with coil loading of 75 mH is 0.033 N per kilometre. With a density of one way station per km., corresponding to conditions on the Belgian network, equation (13) yields a maximum range of 28 kilometres. With two-wire lines of 1.3 mm diameter, the maximum range is 36 kilometres.

8. Amplification.

Circuits of various kinds.

For greater ranges, it becomes necessary to resort to amplification. The introduction of a two-wire repeater into a control circuit entails stability difficulties which are almost insuperable (see paragraph 4 above), and it becomes necessary to sectionalize the circuit into independent sections to which the control office is connected (e.g. at their mid-point) by means of auxiliary circuits with an equivalent of zero. The control circuit proper is thus prolonged by a second circuit which we shall call « pilot circuit ». In the case of an open wire line, the pilot circuit will normally be a carrier frequency channel using the same line, and the way stations must then be fitted with filters. This solution is described in the work by L.W. EAST, already referred to. In the case of a cable, the pilot circuit will be another pair or two pairs of the same cable, according to whether it is a two-wire or four-wire circuit. This choice, in its turn, is dictated by questions of stability of the pilot line, i.e. by the number of sections, the number of branches, etc.

The limitation of the range of a control circuit and the need to sectionalize a circuit of a certain length are due to the impedance irregularities introduced by the way stations and mainly by the more important branch circuits. Through suitable devices for cutting out the branches, it is possible to make the equivalent of the control circuit practically independent of the variable connections of the way stations so that sectionalization is no longer necessary. On the other hand, it becomes necessary to introduce amplification at the source in order to compensate the attenuation of the uncoupling networks and to provide intermediate repeaters where required. All stability difficulties are avoided if the whole of the circuit is arranged as a four-wire circuit. In this case, the controller's microphone is connected to one pair to which the telephones of the way stations are shunt connected. The microphones of the way stations are shunt connected to another pair of wires ending at the controller's telephone.

The mutual audibility of the way stations is ensured by providing a connection between the two pairs at a single point, e.g. at the control office. This solution has the advantage that the line can be extended indefinitely without requiring a pilot circuit.

We must also mention a six-wire system which has been proposed in France, and

which consists of four-wire control circuit sections fed by a two-wire pilot line. The four-wire sections are short enough not to require coil loading so that the long branch circuits no longer present a problem.

It is often necessary to extend a cabled four-wire system by a single open wire line, or to provide a branch line of this kind. The transition from four to two wires at a terminal introduced a loop connection into the four-wire system and might entail « singing » if the relative levels at the connection point are sufficiently different in both directions, even if filters are used. One way of avoiding this drawback is to use the open wire line virtually as a four-wire system by utilizing a different frequency band for each direction of transmission. By adopting the audio-band for the direction from the way stations to the controller, and a double sideband with carrier transmitted in the direction from the controller to the way stations, it is possible to obtain way stations with entirely passive demodulators which do not, therefore, require energy feeding.

In conclusion, the systems used in Belgium, which are described below in greater detail, are these :

a) *Two-wire system* for open wire lines or short cabled circuits, and for short extensions at the ends of four-wire systems;

b) *Four-wire system* for all important cabled circuits;

c) *Two-band system* for open wire extensions or important branch circuits of a four-wire system.

9. Cabled two-wire system.

The figures quoted in paragraph 7, based on a density of one way station per kilometre, have led to a maximum range, without repeaters, of 36 way stations. As the impedance of the cable is 1 200 ohm, the optimum listening impedance of the way stations is of the order of 40 000 ohm. For short branch circuits (less than 50 metres), it is, for economic reasons, not possible to use a branch repeater and to give the stations the highest listening impedance conveniently obtainable, viz. 10 000 ohm. For longer branch circuits (50 to 200 metres), the impedance is increased to 40 000 ohm by means of a repeater with an impedance ratio of 1 in 4. The half-windings of the repeater are connected with each other in such a way as to permit the direct passage of the call current, and the two-mid-points thus obtained are short-circuited for voice frequencies by means of a condenser. This condenser must be sufficiently weak so as not to impair the call current.

During transmission, the optimum impedance of a way station is, in principle, 600 ohm (half the impedance of the cable). But such a low impedance will shunt the line and therefore produce such an irregularity that the use of two-wire repeaters becomes wholly illusory (cf. EAST, *loc. cit.*). It is therefore necessary to increase this impedance to such a value that the reflection caused by it corresponds to an echo attenuation of the same order of magnitude as the attenuation of regularity of the line with its branch circuits. By admitting a figure of the order of 2 N, one finds an impedance of 3 600 ohm. This permits, in principle,

to introduce a two-wire repeater with a gain of 1 N, leaving a margin of 1 N against singing.

The characteristics relevant to the preparation of schemes are summed up below (calculated figures) :

	Short branch circuits	Long branch circuits (with repeater 1 in 4)
Shunt effect for listening.	0.06 N	0.015 N
Branch circuit attenuation :		
transmission . . .	0.55 N	1.25 N
reception	1.05 N	1.75 N

The controller's equipment, having a normal impedance of 600 ohm, is connected to the cable through a 600/1 200 ohm repeater. At the far end, the cable ends in a terminal offering 1 200 ohm to voice frequencies but an open circuit to call currents (resistance and capacitance in series). The separation of call currents and local currents at the controller and at the repeater, if any, is carried out by switches consisting of coils and condensers, the latter being connected at the mid-points of the repeaters. The call current, being A.C., has a negligible saturation effect on the load coils (permalloy powder with a permeability of 120) so that it does not exceed 50 milliamps. A limit of 100 milliamps will in no case be exceeded.

For the maximum range of 36 km, the total circuit resistance of a pair of 1.3 mm dia. wires is of the order of 1 000 ohm and, according to the thesis developed in paragraph 3, the optimum impedance of the selectors lies between 18 000 and 36 000 ohm. The selectors of the existing control system for overhead lines have an impedance of 21 000 ohm; they have therefore been retained. They operate at a minimum voltage of 57 volt and, thus,

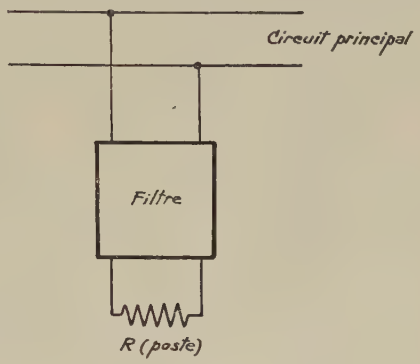


Fig. 4.

Circuit principal = main circuit. — Filtre = filter. — Poste = station.

with a current of 2.6 milliamps. The range resulting from the call current and voltage limitation at the origin of a section is of the same order of magnitude as that resulting from transmission considerations.

10. Four-wire system.

In the four-wire system, using two pairs of wires stranded together in the same cable (quad or spiral quad), the phantom circuit is not coil loaded and is used for call signals without any range limitation other than that resulting from the transmission voltage. If the latter is limited to 100 volt, equation (6) yields the condition :

$$Dn < 2\,000$$

i. e. 45 way stations if the density is one station pr. km.

The branch circuit is the same as that shown in Figure 3, for the « telephone » circuit as well as for the « microphone » circuit. The transformer ratio is so chosen that the normal impedance, seen from the

The principle of the four-wire system is shown in Figure 7. The levels will be discussed with the aid of the block diagram, Figure 8.

The maximum output level of an amplifier using normal low-consumption valves is of the order of +1 N. The range of the

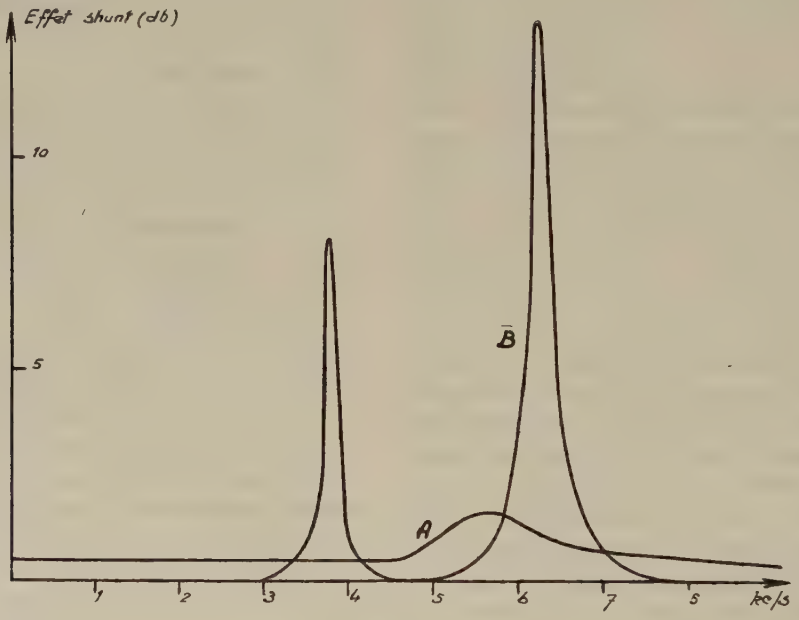


Fig. 5.
Effet shunt = shunt effect.

cable, is 20 000 ohm, there being at least 10 000 ohm at high frequency. This leads to a shunt effect of 0.03 to 0.06 N, and the branch circuit attenuation is 1.75 N for talking as well as listening. The inductance of the high impedance winding of the branch repeaters is at least 13 H so that equation (10) yields a cut-off frequency below 220 cycles pr. second. Figure 6 shows the branch circuit attenuations as a function of the frequency.

section is worked out on the basis of this figure, augmented by the admissible equivalent (2.5 N) and reduced by the branch circuit attenuation (1.75 N) so that its value is also 1.75 N. In the pair of wires destined for the station microphones, the levels shown in figure 8 presuppose that the original zero level is that of the farthest way station of a section. One thus obtains —3.5 N as the lowest input level of the amplifiers. The diaphonic

difference between forward and return wires of a cable is of the order of 10 N but is reduced to about 8.5 N due to the couplings between branch circuit repeaters, and to about 7.5 N (figures measured on the pairs of wires represented in fig. 6) due to the couplings between the induction coils of the way stations. The echo margin at the connection point between the line and the controller's equipment is thus about 5.5 N and, in principle, the loudspeaker at the control office would still be able to supply a fairly high gain through acoustic coupling. In practice, a more severe limit is set by the other considerations mentioned in paragraph 4.

If G is the gain measured between the input of the loudspeaker amplifier via the acoustic coupling to the output of the microphone amplifier, once these amplifiers are so adjusted that the installation has the same electroacoustic equivalent in both directions of transmission as an ordinary four-wire station, it will be seen that the acoustic echo of a remote station returns over the telephone wires at a relative level of G —2.5, whilst that

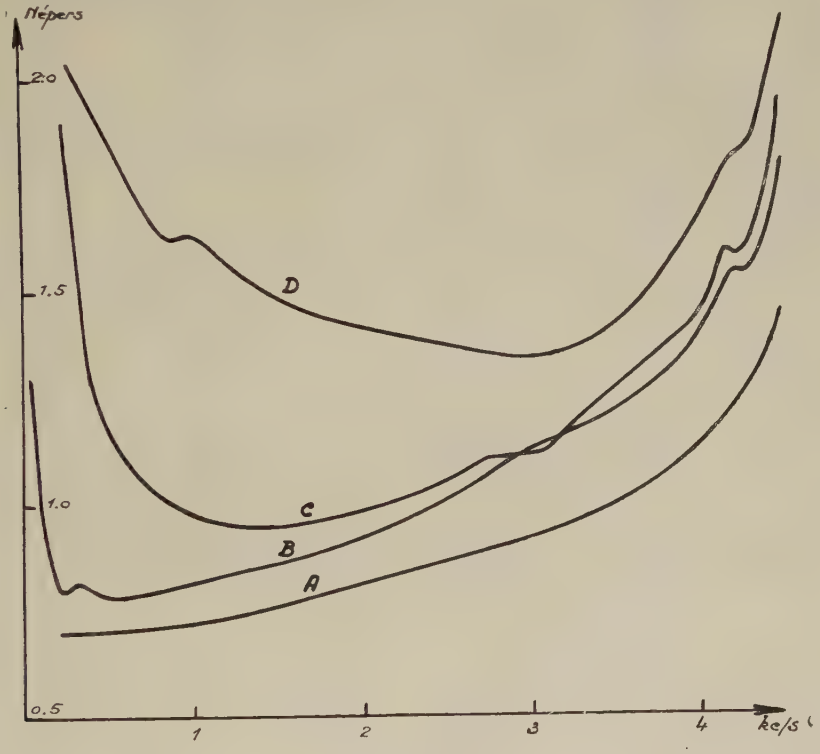


Fig. 6.

Shunt effect on a cable of 68 km (wire of 1.3 mm) with 34 branches.

A. Cable.
B. Cable and branch repeater.
C. Id. + induction coils of the stations.
D. Complete circuit of the « telephone » pair.

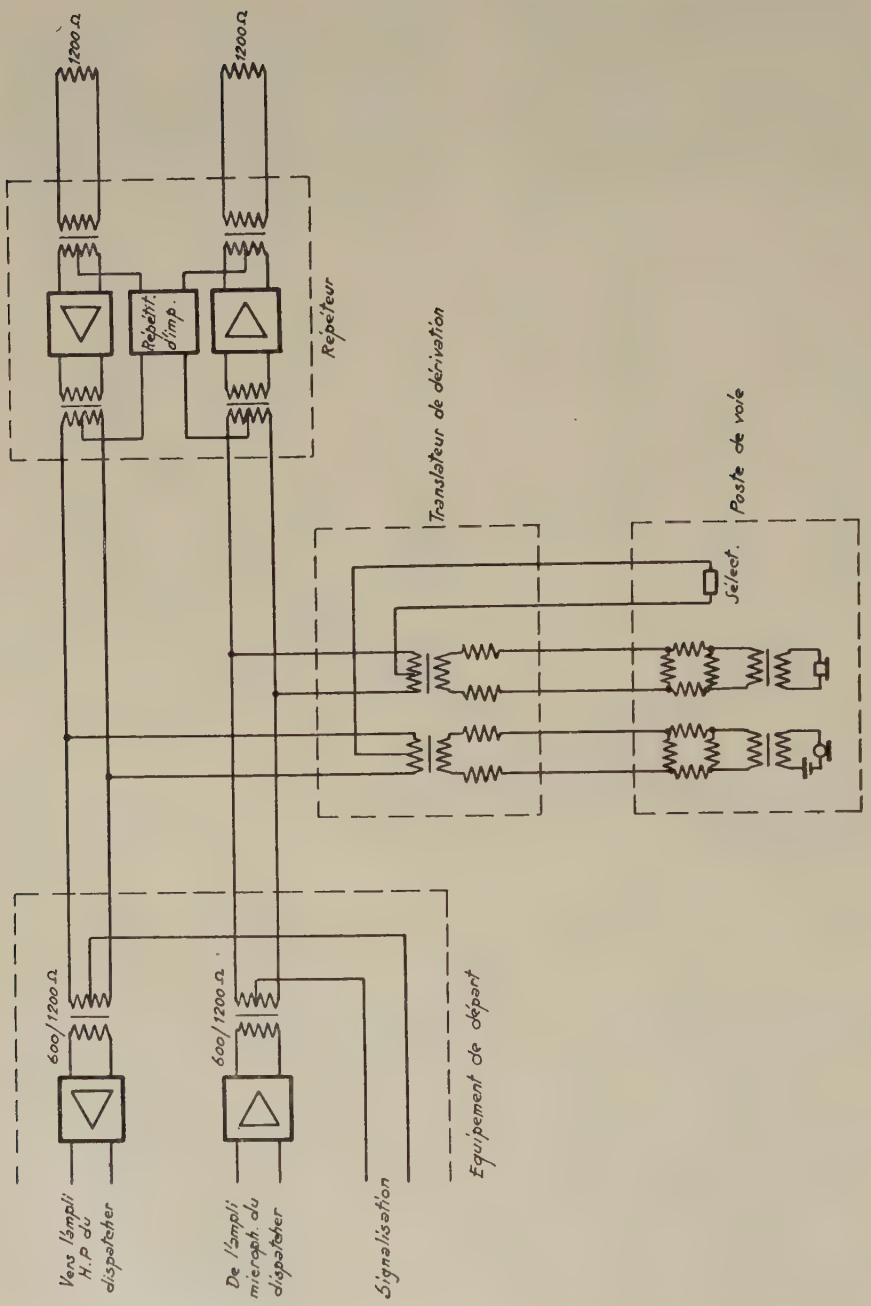


Fig. 7.

Vers l'ampli H.P. du dispatcher = to the loudspeaker amplifier of the controller. — De l'ampli microph. du dispatcher = from the microphone amplifier of the controller. — Equipement de départ = starting equipment. — Répéteur = repeater. — Translateur de dérivation = branch repeater. — Poste de voie = way station.

of a near-by station will be G —2.5 + 1.75 = G — 0.75. Therefore, to avoid saturating the amplifiers, a coupling gain of more than 0.75 cannot be tolerated except if the near-by stations are attenuated by the insertion of 600 ohm attenuators. This has been provided for at four-wire

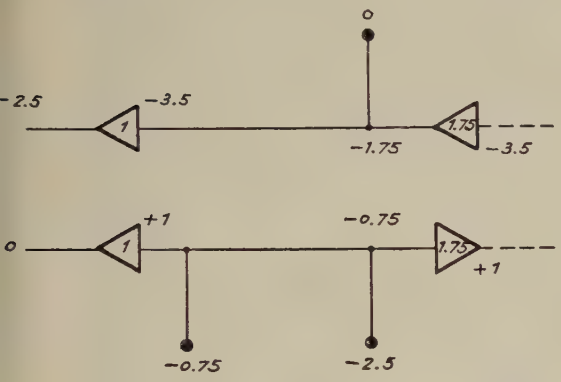


Fig. 8.

stations, and in this case, the limit becomes 2.5 N due to the remote stations. Furthermore, the mutual audibility between one station and another is G—5 N between remote stations and G—5 + 2 (1.75) N = G—2 N between near-by stations. A coupling gain of the order of 0.75 N makes audibility sufficient for the remote stations without making the local effect intolerable at the near-by stations. Here again, improvements can be achieved by making the levels more uniform through the insertion of attenuators. It must be pointed out that a coupling gain of the order of 0.75 N is equally of the order of the regularity attenuation of a two-wire circuit and can therefore not be exceeded if the loudspeaker installation is connected to such a circuit through a terminal.

If the four-wire system is operated with a control station without loudspeaker, the simplest solution is to lead to an ordinary two-wire station through a hexapole giving attenuation B. The gain of the end amplifiers must be increased by A in both directions so as to restore the levels at the control station, so that the coupling gain is C = 2 A — B. In particular, if one takes as hexapole a star of resistances, one obtains A = B = C = 0.7 N.

Each pair of wires of the complete circuit shown in figure 7 has an end to end loss of 0.75 N so that the loss in the complete circuit is 1.5 N — C, i. e. 0.75 N with the loop gain admitted. By removing the terminal resistances, it is therefore possible to connect two such circuits back to back. The stability margin is adequate, and a conversation between opposite control offices is obtained with an equivalent of 1 N on four-wire (because a nominal level point — 1.75 N of the first circuit connects with a nominal level point —0.75 of the second circuit).

11. Two-band system.

The principle of the two-band system is shown diagrammatically in figure 9. An originating (active) circuit connects a four-wire system to the open wire line, if necessary by means of a four-wire repeater (not shown) to ensure the adjustment of the levels. An end circuit (passive) enables the circuit to pass back into four wires for an extension in cable or the insertion of an audio repeater. The end circuit is similar to that of the way stations, except that the latter is of the high impedance type. Where it is not necessary to revert to four wires, the end circuit is simply omitted.

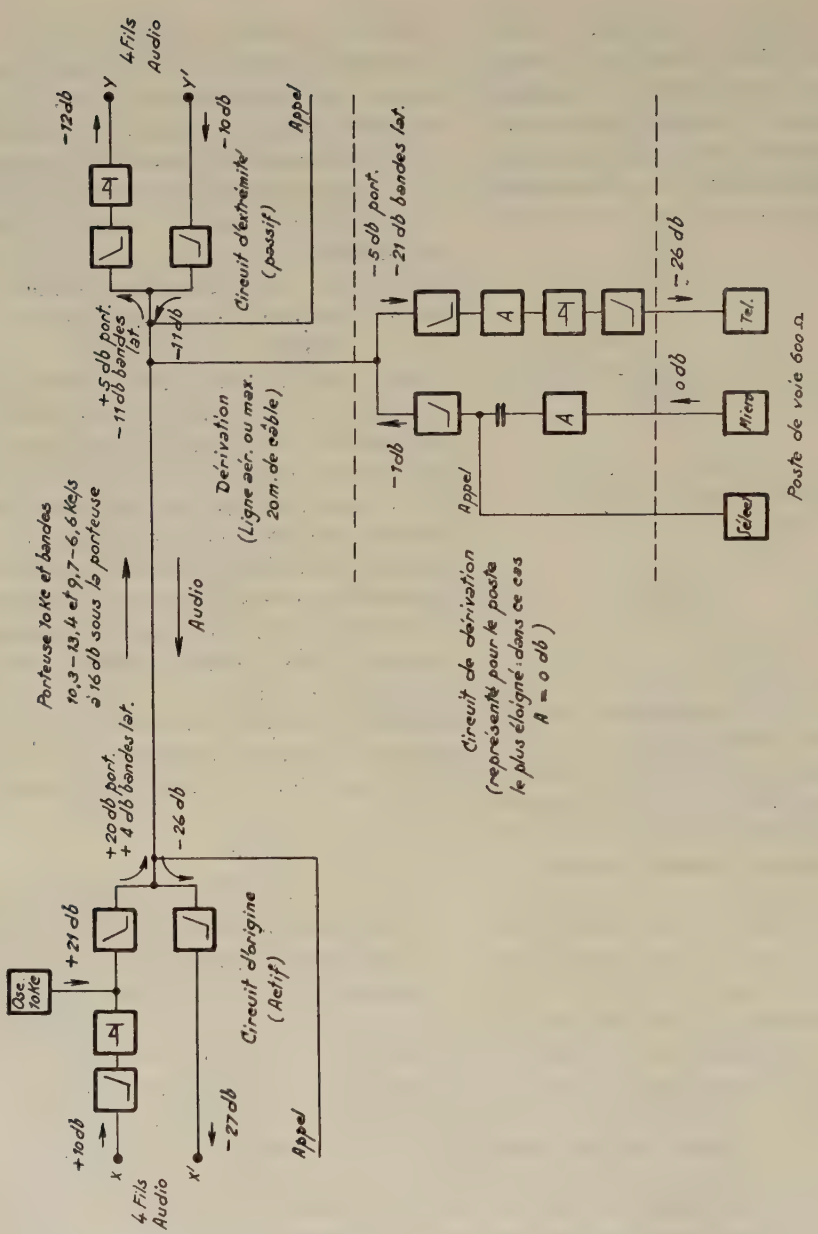


Fig. 9.

4 fils audio = four-wire audio circuit. — Circuit d'origine (actif) = original circuit (active). — port. = carrier. — Bandes lat. = frequency sidebands. — Circuit d'extrémité (passif) = end circuit (passive). — Appel = call. — Dérivation (Ligne aér. ou max 20 m de câble) = branch (overhead line or maximum 20 metres of cable). — Circuit de dérivation, représenté pour le poste le plus éloigné = branch circuit, shown for the most remote station. — Poste de voie = way station.

Transmission towards the way stations takes place at the carrier frequency of 10 kilocycles with two sidebands. A good separation is thus ensured between the upper limit of the audio band (3.4 kilocycles) and the lower limit of the carrier band (6.6 kilocycles) so that filtering becomes easier. The modulators are

of the type described by E. C. BLESSING [10] and consist of cuprous oxide rectifier units.

The insertion of a filter in the branch circuit raises some difficulties which we shall examine with the aid of the diagram, figure 4.

In the first place, the filter works between a source of an impedance W/2 (main circuit with characteristic impedance W on either side) and a receiver with the impedance R which is normally much greater than W because of condition (4). The filter can, however, not cope with the internal impedance transformation adapting W/2 to R because, terminated by R, it must offer the main circuit an inlet impedance of the order of R so as not to exceed the shunt effect envisaged. A standard filter, calculated for nominal impedance of the order of R satisfies the second condition, but would have an inadmissible response curve when faced with a source of weak impedance, W/2. It is, however, possible to calculate filters which satisfy both conditions simultaneously, using unconventional methods. In fact, since $W/2 \ll R$, this amounts to calculating a filter working in short-circuit on one side of the line. The methods are similar to those used for the calculation of filters working with open circuit on one side of the line such as certain input or output amplifier circuits. One can either use the method outlined by S. DARLINGTON [8] or modify a standard filter in accordance with a calculation method outlined by V. BELEVITCH [9].

A second difficulty arises from the fact that the shunt effect on the main circuit must remain weak even when the filter outlet is open (way station disconnected or connected). In this case, the filter, seen from the main cable, is a purely reactive di-pole and presents a number of resonances and anti-resonances which is the higher the more complicated the structure. For the types of filters suitable for this purpose (input impedance of the K-constant half-series type so as to have a high impedance outside the band used and consequently a negligible shunt effect for the other bands), it can be shown that all these resonances and anti-resonances are of necessity in the pass band. However, for relatively simple filters, these resonances are fairly close to the cut-off. The shunt effect of such an open circuit filter will therefore follow the curve shown in figure 5 where the resonances provoke high peaks of the shunt effect, damped merely by the dissipation of the filter coils. These peaks are not harmful if they fall outside the useful part of the cable spectre as shown in Figure 5. For simple filters (with bands comparatively separate), this condition can be fairly easily fulfilled by taking a cut-off frequency which is sufficiently out of phase in respect of the practical limit of the band (*).

(*) For more complicated filters, the resonances are too numerous to be admissible, and must be damped by a resistance terminating the filter. In this case, the normal load is the combination, in parallel connection, of the damping resistance and the way station. This obviously results in an additional attenuation. This difficulty is avoided in the case of stations with constant impedance (fork contacts connecting a resistance when the station is reconnected). In this case, it is necessary to make sure to reconnect the same resistance when the station is taken out, e.g. for repair. The difficulties become still greater in the case of treadle operated stations with different impedances for talking and listening. In this case, one solution consists in equally commuting between two filters of different impedances.

The filter requirements for the filters of the original circuit result from the fact that the echo in the four-wire system must be of the same order of magnitude as in a four-wire audio system. This echo is due, partly to the passage of the audio signal because of the unbalance across the modulator, and partly to the non-linear effects in the coils of the directional filter itself; these effects are here more serious than in the normal two-wire systems as it is a problem of a detection effect of the first order.

At the way stations, the filter requirements are easier. In the first place, a certain filtering is necessary in order to permit the parallel connection of the telephone and microphone circuits without shunt effect of the one on the other. In the second place, the filters must prevent the whole arrangement of audio band + modulated carrier frequency from becoming transformed, one to the other, through intermodulation in the modulator or in the microphone. Such an intermodulation in a near-by station would give a four-wire echo to the origin which would merely be reduced by the branch circuit attenuation there and back. For a remote station, the echo is further diminished by twice the line attenuation. It is therefore advisable to make the levels uniform and at the same time to reduce the filter requirements by inserting attenuators immediately behind the directional filter of the way stations.

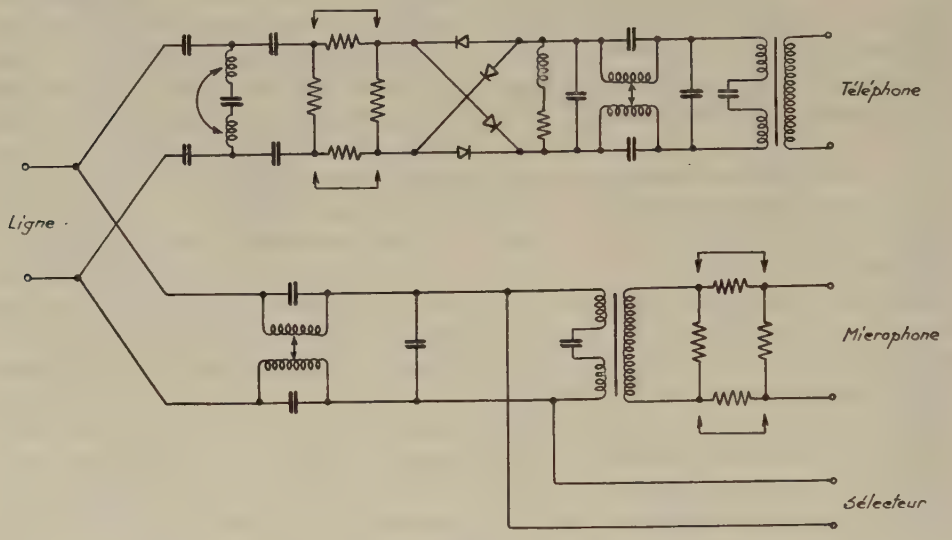


Fig. 10.
Sélecteur = selector. — Ligne = line.

Figure 10 shows the details of the branch line circuit. The filters are designed to work between a low impedance and 5 000 ohm whilst presenting to the line an impedance of the order of 5 000 ohm. The low-pass filter behind the demodulator blocks the rectification remnants of the carrier, hence the double frequency (20 Kc) and

the direct current. To enable the modulator to function, it is however necessary to provide a load (inductance and resistance in series) for the direct current. The voltage rectified at the terminals of the resistance serves to control the carrier. The shunt effect of the filters follows the curve shown in Figure 5.

The range of a two-band system is mainly limited by the attenuation of the carrier due to the line and to the shunt effect of the branches. In fact, a reduction of the carrier level causes the efficiency of the passive demodulators to fall rapidly. It is therefore advisable to transmit the highest possible energy. The choice has fallen on a transmission level of +2.3 N (100 mW), normally used for carrier current systems on overhead lines. It is also advisable to limit the attenuation due to the branches by limiting the length of the branches (to, say, 30 metres). If local circumstances call for a longer branch circuit, the filters with the demodulator will nevertheless be placed quite close to the line even if it may mean linking them with the station by means of a local cable with three pairs of conductors.

The signal is emitted with a modulation rate of 16 %, corresponding to a difference of 1.85 N between the levels of the carrier and the sidebands and permitting the demodulation within suitable limits of non-linear distortion.

PART II.

IMPROVEMENT OF THE EQUIPMENT.

1. General.

In view of the heavy traffic (varying between 80 and 250 trains or movements per day on each of the lines subject to traffic control), it has been deemed necessary to make the new installations as perfect as possible so as to enable the controllers to concentrate on their actual job of regulating the traffic. Among the perfections designed to give the controllers the best facilities, the following ones have been adopted :

— the use of a loudspeaker telephone set without treadle for the change of talking direction, permitting an extremely rapid exchange of communications (paragraph 2);

— calling the way stations by means of a simple operation, viz. the momentary pressing down of a single-push-button for each way station required (paragraph 3);

— rapid communications with other officials, both with those located in the same control office (paragraph 4) and with those of the outdoor services (paragraphs 8 and 9).

It has not been deemed necessary to bring about communications with running trains. The line equipement is described in paragraphs 5, 6 and 7.

2. Loudspeaker telephone sets.

The replacement of the microphone (often of the breastplate type) and the earpiece (often of the headphone type) by a microphone-cum-loudspeaker set with associated amplifiers has the effect of making the conversation more akin to direct talk; on the other hand some new problems arise :

a) The loudspeaker must have a sound level comparable to that of a person

talking (if possible, between 55 and 75 phones) (*);

b) The loudspeaker must have a clarity at least equal to, if not greater than, that of the earphone, as the ear is less tolerant when both ears take part;

c) The way stations must be able to hear at least as well (in regard to sound level and clarity) as if the controller would be using a normal set;

d) The acoustic energy released by the loudspeaker towards the microphone must not be too strong (danger of « singing » in the telephone circuit, danger of saturation of the amplifier associated with the microphone, and risk of a considerable increase of the local effect of the way stations if the coupling is such that the voice of a microphone at a near-by station is stronger than the voice normally used by the controller);

e) The acoustic energy reverting towards the microphone or the « telephone » circuit must be so great that the second way station can appreciate the position and does not break into a conversation going on between the controller and a first way station.

Condition *a)* is satisfied, to the extent permitted by *d)* (stability), if the amplification is effective enough (of the order of 4 to 5 Nepers) for a signal received from the line at the relative level (**) of —2.5 to —3 Nepers to give the loudspeaker an energy of the order of 250 mW (*).

In order to obtain adequate clarity (condition *b*), it is necessary to take into account the quality conditions for all the transmission elements connecting the way stations with the control office. The measures taken in this connection are :

— line transmission of all voice frequencies from 250 to least 3 600 cycles pr. sec. (so that coil loaded cables, if any, must have a cut-off frequency of at least 5 kilocycles);

— (possible) use of telephone repeaters and of a loudspeaker amplifier producing a very small non-linear distortion (less than 1 %);

— use, at the way stations (see further down below), of modern microphone cases with improved characteristics as regards linear as well as non-linear distortions. In practice, the most important residual distortions of the system are those emanating from the way stations.

Numerous comparative tests have shown that a high-quality microphone is required to meet condition *c)*. The choice between a piezoelectric type and an electrodynamic type is a matter of convenience. The electrodynamic type with low impedance has been adopted as it permits, with passive organs (repeaters etc. with the exception of thermionic valves) the adaptation to the connecting line of the amplifier which is, in some cases, located some hundred metres away.

(*) The « phone » is a logarithmic level sound unit which takes into account the different degree of audibility according to the quality of the sound; the minimum (0 phone) corresponds to the lower limit of audibility, and 130 phones to the limit at which the sound causes pain.

(**) The relative levels are defined in relation to the reference level of 1 mW.

(*) For a loudspeaker giving a level of + 90 db above the audibility level of 10^{-16} W pr. sq. cm pr. Watt of electric energy at 80 cm distance from the loudspeaker, which is the normal distance of the controller.

The indispensable clarity (condition *c*) calls for an effective treatment of the walls of the room. The microphone must mainly react to the direct sound wave coming from the mouth of the controller, and not to the multiple indirect sound waves reflected by the walls, furniture etc. The latter waves would surround the spoken word with a « halo » which would reduce its clarity considerably. A lining with sufficient absorption capacity (absorption coefficient of at least 65 %) is applied to the ceiling and walls from a height of about 80 cm above the floor. Glazed surfaces are reduced to a minimum, windows are curtained. The reverberation time is reduced to less than 0.35 seconds.

It is also of importance to install the microphone as close as possible to the controller, without however impeding him in his graph work. This apparatus has been built flush into the desk, close to the front edge, below a series of holes made in the desk plate. It often happens, therefore, that the microphone is covered with paper. However, the additional sound damping, especially at higher frequencies, resulting from this fact is not harmful; it is, in fact, partly compensated by an increasing gain in frequency of the associated amplifier.

The amplifier associated with the microphone (*) must furnish a fairly considerable gain (3.5 to 4 Nepers) and greatly reduced non-linear distortions in a range from 100 to 6 500 cycles pr. sec.

The most difficult conditions to be fulfilled are the contradictory ones listed above under *d)* (stability) and *e)* (minimum coupling).

The stability condition imposes a limit to the gain measured between the loudpeaker amplifier and the output of the microphone amplifier, through the acoustic coupling between loudspeaker and microphone. The condition can of course be partly met, as is usual especially with two-wire repeaters, by means of a filter which cuts out the higher frequencies not transmitted by the cables (frequencies above 4 kilocycles pr. sec.). In practice, the acoustic coupling is strongest at low frequencies (below 150 cycles pr. sec.) which justifies the use of a high-pass filter.

The required stability is fairly easily obtained with the four-wire and two-band installations described earlier on because there is, in principle, no second channel to close the loop between one pair of wires and the others. It is however necessary to reckon, firstly, with the subsisting couplings (diaphony of the cables, couplings between branch circuit repeaters and between induction coils of way stations) and, secondly, with certain exceptional circumstances (coupling at the far end when two circuits are interconnected, coupling through lack of balance at the terminals of the two-wire lines or branch networks).

The line level considerations outlined above are not, in themselves, the only criterion for fixing the levels and amplifications at the control station. Conditions *d)* and *e)* require that the microphone retransmits to the line with an attenuation of at most 25 to 30 db the word received through the loudspeaker, but always so that the attenuation remains positive. It is desirable that the attenuation reaches

(*) The microphones used are of the electrodynamic type (Type 3635 A) with an efficiency of 70 microvolts pr. barye at a distance of 30 cm on an impedance of 25 ohm.

10 to 15 db over the whole range of frequencies transmitted.

It is very difficult to realize these values with two-wire lines. That is why the latter are only very little used in modern installations.

a microphone of suitable directivity. The transmission of low frequencies which mainly takes place through the mass of the controller's desk, is countered by an elastic suspension of loudspeaker and microphone as well as by a fluff of cotton

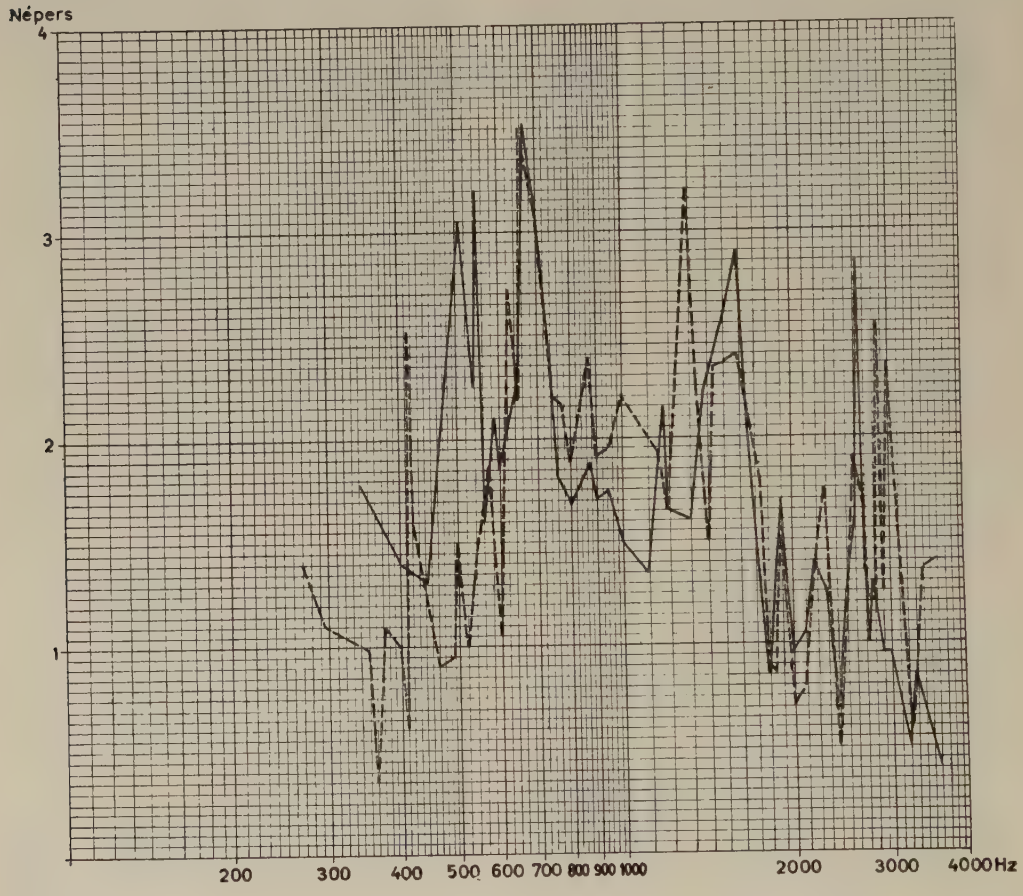


Fig. 11.

The coupling between loudspeaker and microphone is greatly reduced by the lining applied to the ceiling and walls of the premises. Matters can be further improved, at high frequencies, by using

placed in the table. Calculation is thus obviously difficult; one has therefore resorted to tests. Figure 11 shows two curves thus obtained. It reveals a mean uncoupling effect of 20 db, which shows

that a solution complying with the diverse stipulations is possible. In consequence, the microphone amplification supplies a relative level of about 0 db at the inlet to the line (before the repeater), which is the level of a normal telephone set, whilst the loudspeaker supplies a sound level of the order of 60 phones for a signal entering at the relative level of —2.5 Nepers.

The combination of these measures results, at the way stations, in a very good « sonority » for the controller's voice; but that of the other way stations remains feeble because of the cumulative effect of the non-linear distortions of the microphones of those stations and the deformation of the acoustic coupling between the loudspeaker and microphone of the controller.

The following auxiliary devices have been provided for :

— the possible use of an ordinary microtelephone to replace the entire loudspeaker set in case of a breakdown of any of its parts;

— the possibility of reinforcing by 1 Neper (8.7 db) the amplifying power of each of the two amplifiers employed; this reinforcement of one of the directions of transmission is accompanied by the short-circuiting of the other direction in order to have a radical means of preventing any circuit instabilities. This operation is carried out by switching a three position telephone key backward or forward; in analogy with the older installations, this device is called « treadle key ».

The arrangements resulting from all these considerations have led to the provision of desks on which all the necessary organs are conveniently arranged, as shown in Figures 12 and 13. The distance between controller and microphone is about 30 cm; that between controller and loudspeaker is about 80 cm.

In front of the official is the theoretical graph timetable, in form of a sheet covering a period of six hours at a time. By means of interchangeable frames, the theoretical graph timetable sheets can easily be replaced, and it is even possible for the official to have two of the sheets in front of him at the hours when these sheets overlap.

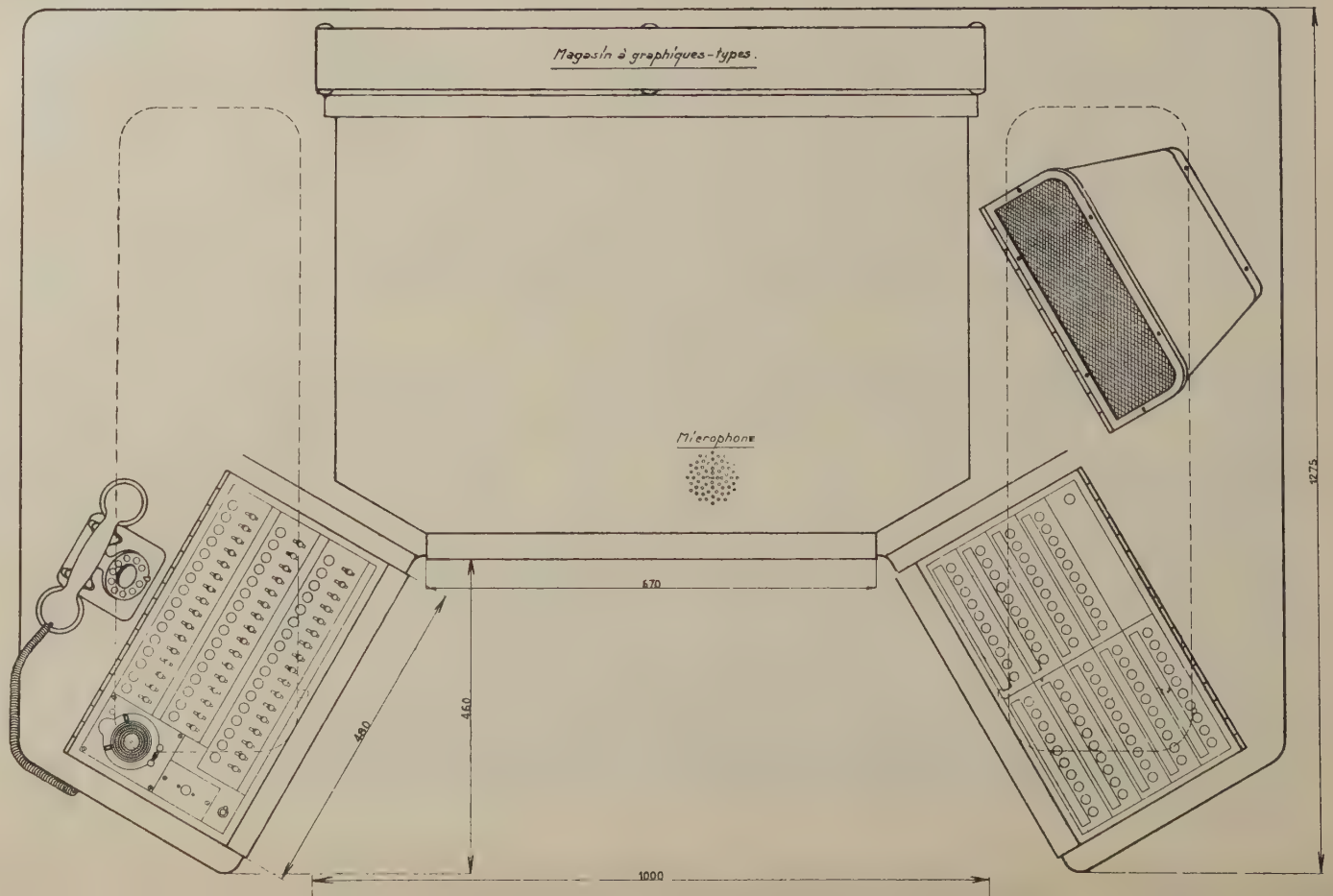
Tests and checks have confirmed the figures given above. In practice, the auxiliary devices are only used in exceptional cases.

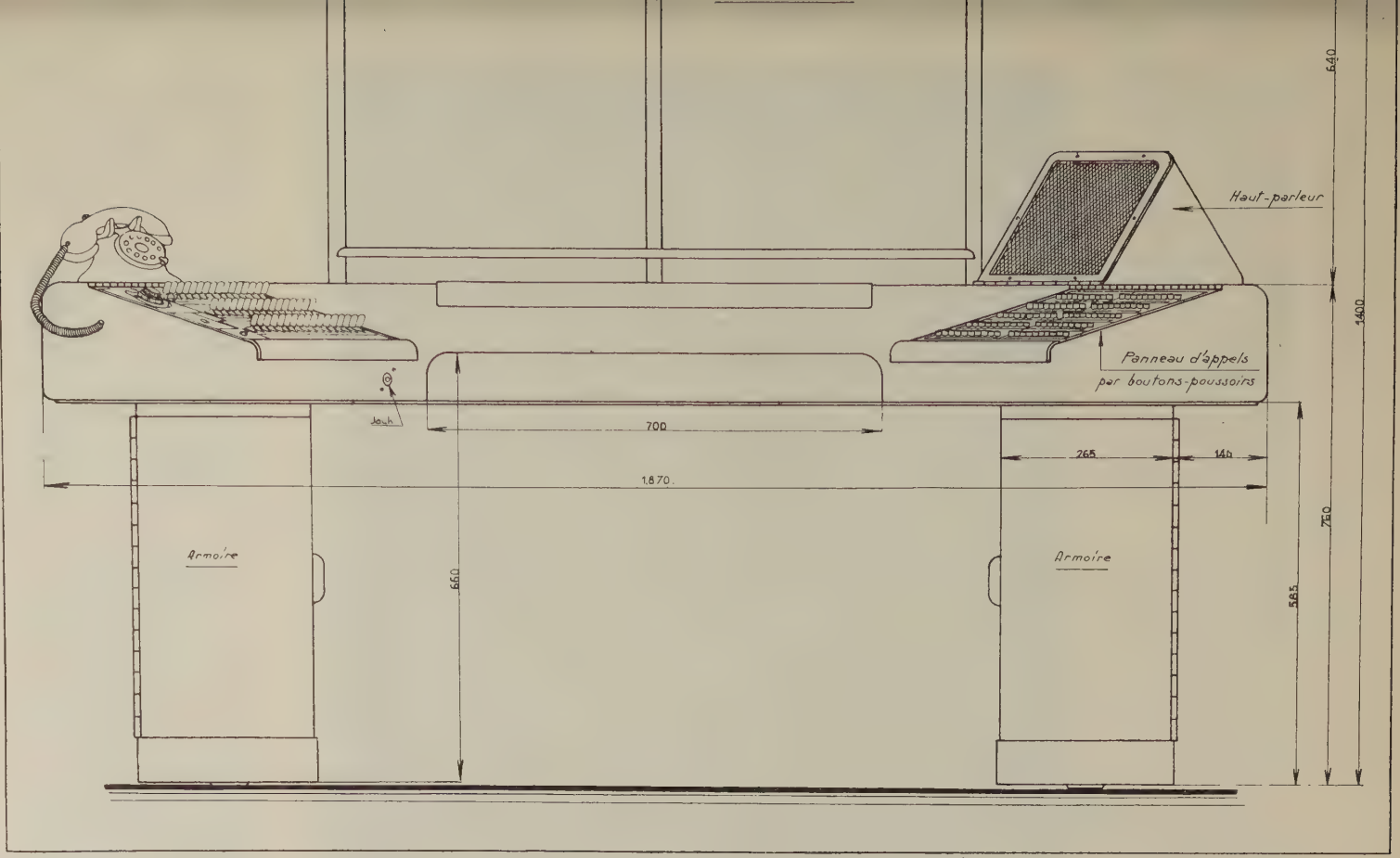
3. Transmission keyboard for call signals.

An important supplementary facility has been obtained through the modernisation of the call installations. The old keyboards which occupied much room on the desk, obstructed the view and required a certain physical effort for the handling of each key, have been replaced by a keyboard let into the desk within reach of the right hand, and comprising one key or push-button for each way station to be called (fig. 14). This keyboard also contains some special keys (group call, general call, hourly time signal, prolongation of call signal) and a control lamp.

Each push-button carries only a few contacts (the maximum being three). To initiate a call to one station, it is sufficient to press down the corresponding (instable) push-button, and this only for a few seconds. The associated relay apparatus (fig. 15) registers this action

FIG. 12


Magasin à graphiques-types.
Microphone
670
460
580
1275
1000



Magasin à graphiques types = stock of standard graph timetables. — Haut-parleur = loudspeaker. — Panneau d'appels par bouton-poussoir = push-button call panel.

by charging two condensers determined by the push-button concerned, and controls the impulses sent out over the line. It may be mentioned in passing that the push-buttons have different colours according to whether the way station concerned is a signal cabin, a station, a depot, etc.

way stations comprise (in accordance with the Western Electric system) a constant total of 17 impulses, divided into three « trains » with the aid of cuts provided at points characterizing each code. Each train must however consist of at least two impulses (*).

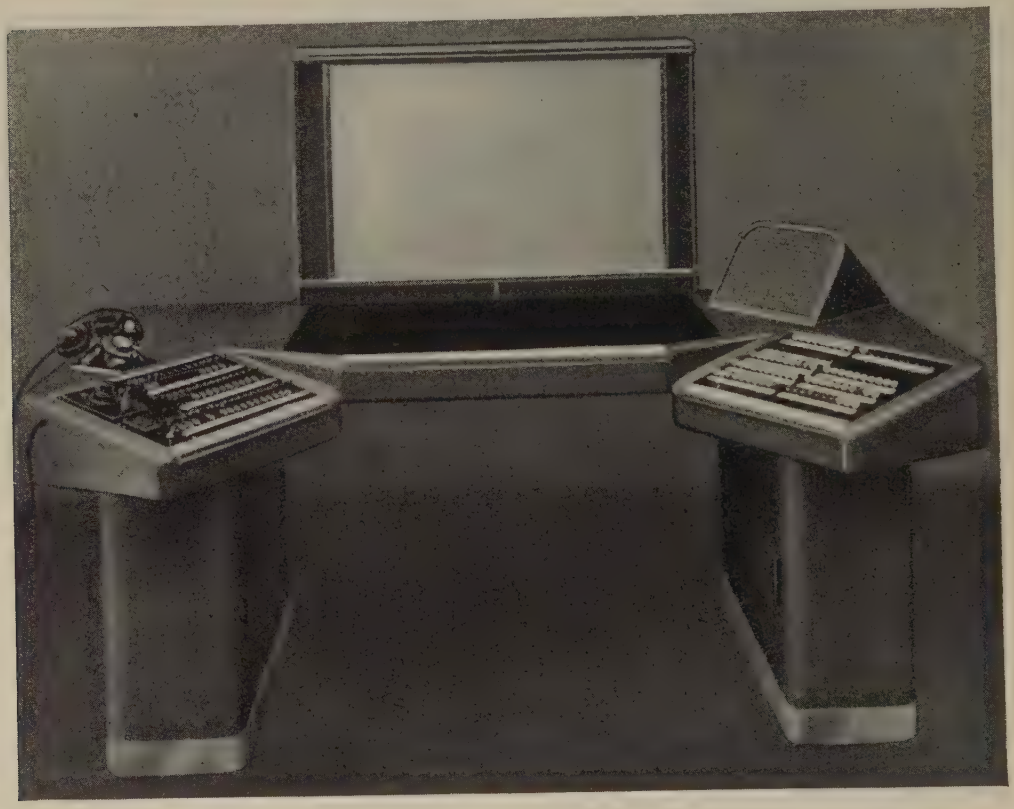


Fig. 13.

The relay apparatus comprises, in addition to the condenser set, a rotary selector which explores successively the potentials of each of the condensers, an impulse generator which moves the selector, and some associated relays.

The codes used for the calling of the

(*) If n is the constant total number of impulses contained in each code, the number of possible different codes amounts to :

$$1 + 2 + ... + (n - 5) = \frac{(n - 4)\,(n - 5)}{2}$$

i.e. 78 combinations for a code with 17 impulses and 136 combinations for a code with 21 impulses.

The limitation imposed by a minimum of two impulses in the first and third train shows that the code cuts can be effected at fourteen different points. That is why the transmitter contains fourteen condensers, all of which are, incidentally, with the call impulses sent out to the line, at the rate of one step per impulse, i.e. with a frequency of about 3 1/2 cycles pr. second. During that rotation, a selector brush tests successively the load potentials of the fourteen condensers.

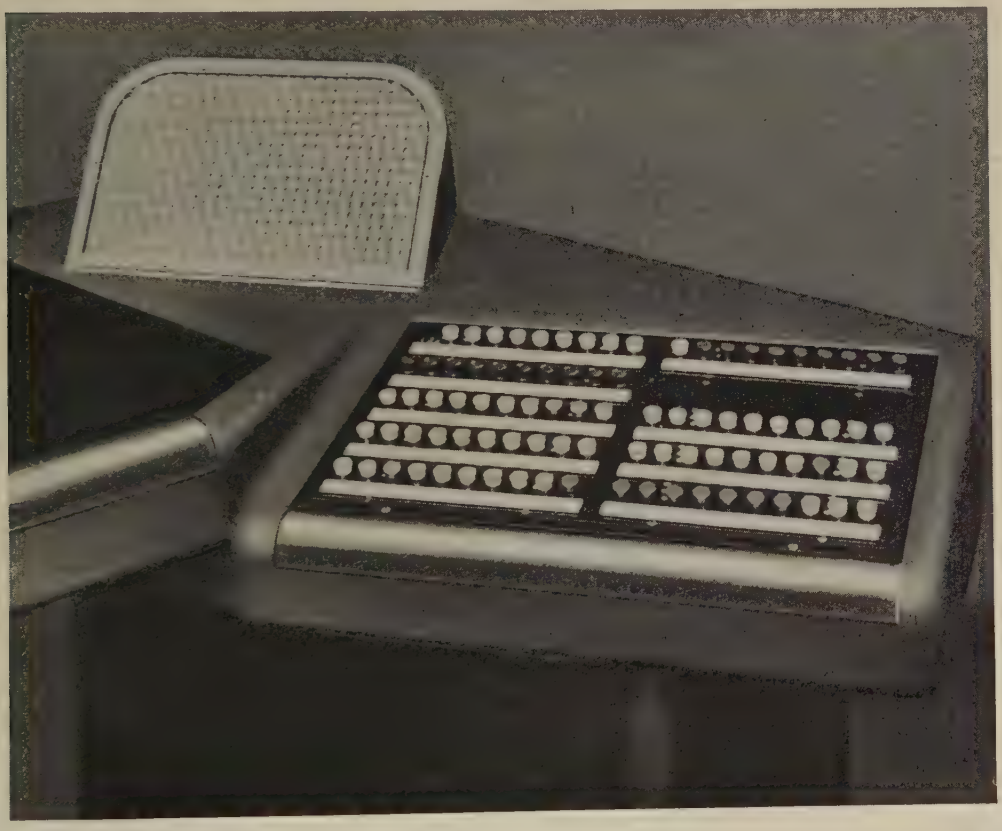


Fig. 14.

of equal value. As already mentioned, any two of these condensers are brought into play (by potential charge) every time, one of the push-buttons is momentarily pressed down.

The rotary selector (of the type used in automatic telephony) moves in step As soon as a loaded condenser is encountered, the brush stops for a brief moment (or rather drops momentarily to a four or five times slower speed) and thus marks the end of the first or second train of impulses, as the case may be.

In practice, the two rates of speed are

governed by an impulse generator. The modification of the speed is obtained by changing the value of a condenser, i. e. of a time constant.

The generator carries a polarized relay

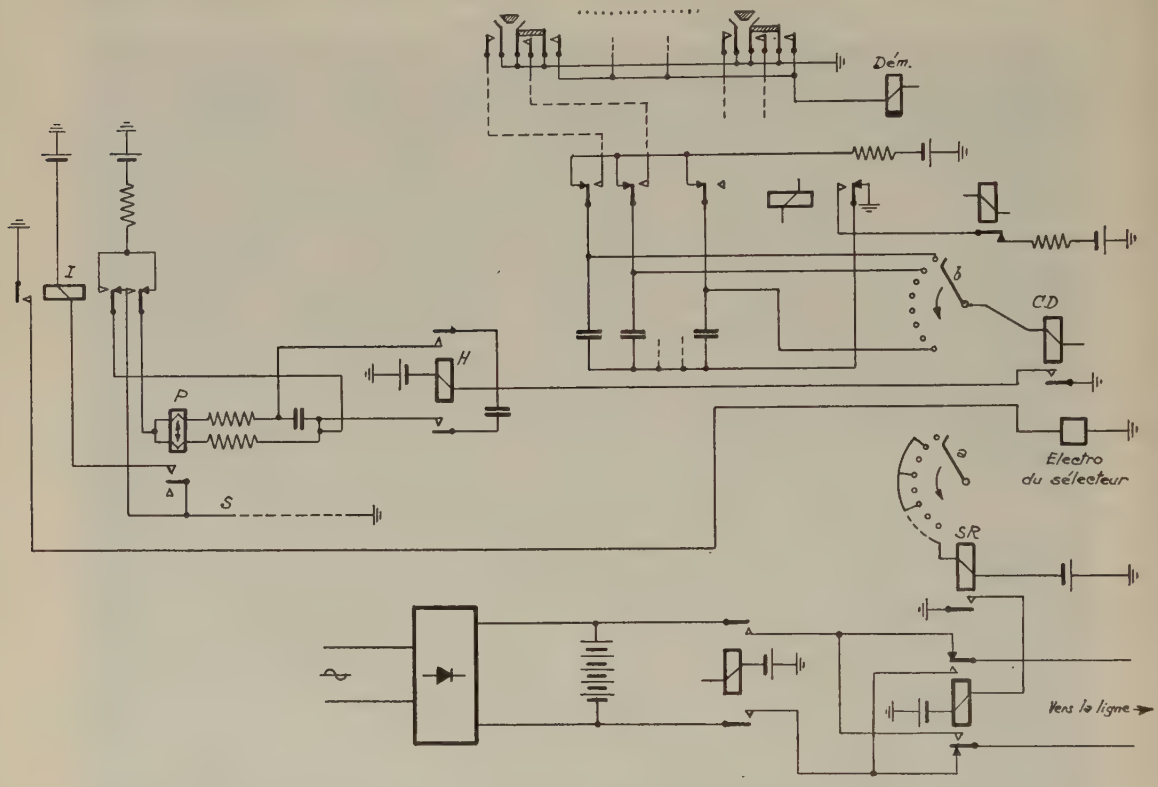


Fig. 15.

(P) and two satellite relays (I and H), as shown in diagram, Figure 15. As soon as the wire S (starter) is earthed, the two opposed windings of P are alive with currents dependent on the time constants of the corresponding circuits. When the current running through the winding with condenser has become too weak and the other winding is energized, the contact of P closes and causes I to operate. At that moment, the polarity of the currents passing through the windings of P is inversed, and the process begins afresh as the condenser is loaded in the inverse direction. The end of each impulse is marked by the operation of the relay I. Relay H is used to change the time constant of operation.

The selector possesses two arms : the first of them energizes a beater relay (SR) at every other step. In this way, the polarity of the impulse sent out on the line is reversed, which is necessary because

the selector-receivers of the way stations are polarized.

The other arm of the selector has the function of exploring the different condensers by connecting them, one after the other, with the test relay CD. The condensers are charged at rest. When a push-button is pressed, the charging circuit is interrupted. The two condensers are selected by the push-button and receive a charge of a polarity opposed to their load at rest, whilst the twelve other condensers keep their charge with normal polarity. Thus, when one of the selected condensers is tested, relay CD is energized successively by the discharge current of that condenser and by the recharging current with normal polarity. This device makes the working doubly safe. The working of relay CD causes the operation of relay H of the impulse generator which thus drops to slow speed so that the current is interrupted between two successive trains of the call code.

As already explained, the first arm of the selector operates the beater relay SR every time a step of even number is passed. This relay SR governs the transmission to the line of the selection impulses, the current being supplied by a continuous source (accumulator with buffer rectifier) with a voltage appropriate to the line.

In pratice, there are as many impulse transmission relays as there are different branches on the line. This arrangement has been adopted in order to reduce the noise that might occur in the case of an accidental unbalance of the wire/earth impedances in one of the branches.

Generally, the voltage is one of 100 to 110 volts when the impulses are transmitted through the phantom circuit (combination of a quad, in the case of four-wire circuits, as explained in Part I). Often, 220 volts are chosen when the line is of the overhead type. If the line is long, it is also possible, as explained further down, to make use of retransmitters or impulse re-generators.

The relay apparatus just outlined comprises, in addition, the following supplementary facilities :

— call prolongation (extending the duration of the call from 2.5 to about 10 seconds);

— cancellation of a call signal during its transmission when the controller has become aware of having pressed a wrong push-button;

— possibility of a group call, by suppressing an interruption during the transmission of a code;

— possibility of a general call to all way stations (which can be done simply by sending out an uninterrupted train of 17 impulses);

— possibility of transmitting hourly time signals (train of 23 impulses, followed by six isolated impulses), either by means of a push-button specially provided for this purpose, or automatically by means of a contact operated by an electric clock (e.g. a master clock); in the latter case, an advance contact of the electric clock blocks the key board in such a way as to prevent the transmission of any call signal which might jam the time signal.

An accessory relay is used for disconnecting the impulse generator after the transmission of the complete code so as to enable the test selector to revert very

rapidly to the rest position and to be available for the transmission of another call.

It may still be mentioned that each desk is also equipped with a general call key of the old type so as to guard against any breakdown in the tabulator and its associated apparatus. As an aid to memory, the positions into which the two indices of that key must be placed to call a given station are indicated below the push-button by which that station is normally called. This key is very seldom used.

Finally, an excess current relay has been provided which acts as a circuit breaker in the case of a short circuit on the outside line. This relay is placed on the frame of the apparatus. Its working is indicated by a pilot light on the controller's desk; it can be re-set by remote control by means of a push-button.

4. Grouping of officials and supervision in a regional control office.

The working conditions of a regional control office equipped with loudspeaker type telephones of the kind described above call for a fairly effective isolation of the microphones against various noises (noises from outside, conversations of other officials). The different desks should therefore be separated from each other, each being placed in a separate cabin the walls of which are covered with materials of high acoustic absorption capacity.

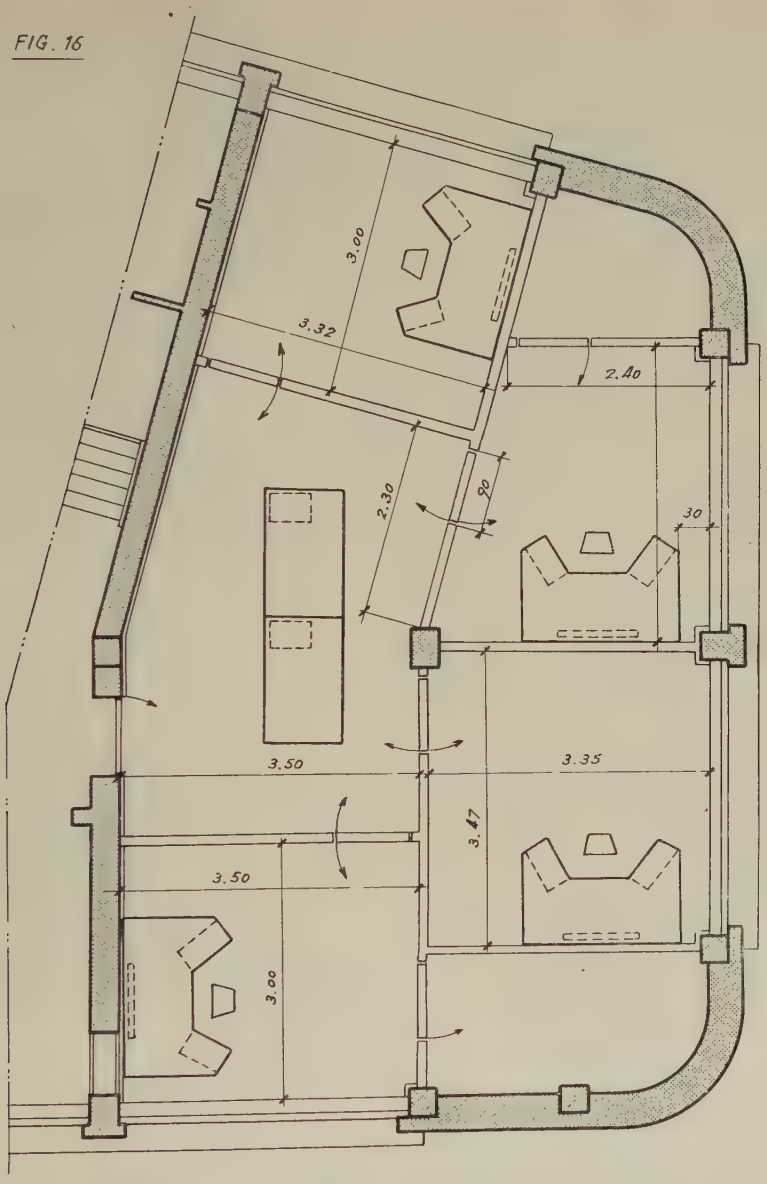
However, in a regional control office, it is necessary to mind, amongst other things, the most economic use of the motive power available, the carrying out of instructions of the central office for the allocation of goods wagons, the efficient utilization of train staff, the supervision of perishable and registered consignments, etc. For these activities, the individual controllers must act in unison; they must, moreover, be assisted by other officials (liaison officials) and must be supervised by a Chief Controller. In the case of electrified lines, coordination is required with the officials responsible for the load distribution of the traction substations and with the allocation of electric motive power units.

The problem of intercommunications between different officials, even if they are located in premises remote from each other, has been solved by the provision of direct and rapid telephone communications. For this purpose, use is made of the micro-telephone placed on the left hand side of each desk as well as of the key and call lamps on the left-hand panel of the desk (as many keys and lamps as there are possible communication channels, there being one key per channel). By lifting the receiver, the microphone associated with the desk loudspeaker is automatically disconnected so as to ensure the secrecy of local communications of the control office (the loudspeaker remains in service so as not to interrupt vocal calls coming from the way stations).

The supervision by the Chief Controller over all the lines controlled by the regional office is carried out within view and requires, first of all, a suitable grouping of all the individual control cabins which should, if possible, be arranged in star-fashion around the table of the Chief Controller. Figures 16 and 17 show two examples of layouts actually adopted.

This supervision is likewise assisted by telephonic means. It is carried out

FIG. 16



by means of a control loudspeaker linked with a special multiple-inlet amplifier (fig. 18). This amplifier is of the two stage type, the first stage comprising as many separator tubes, parallel connected on the anode side, as there are lines over which the supervision is to be exercized. The « entry » side of each separator

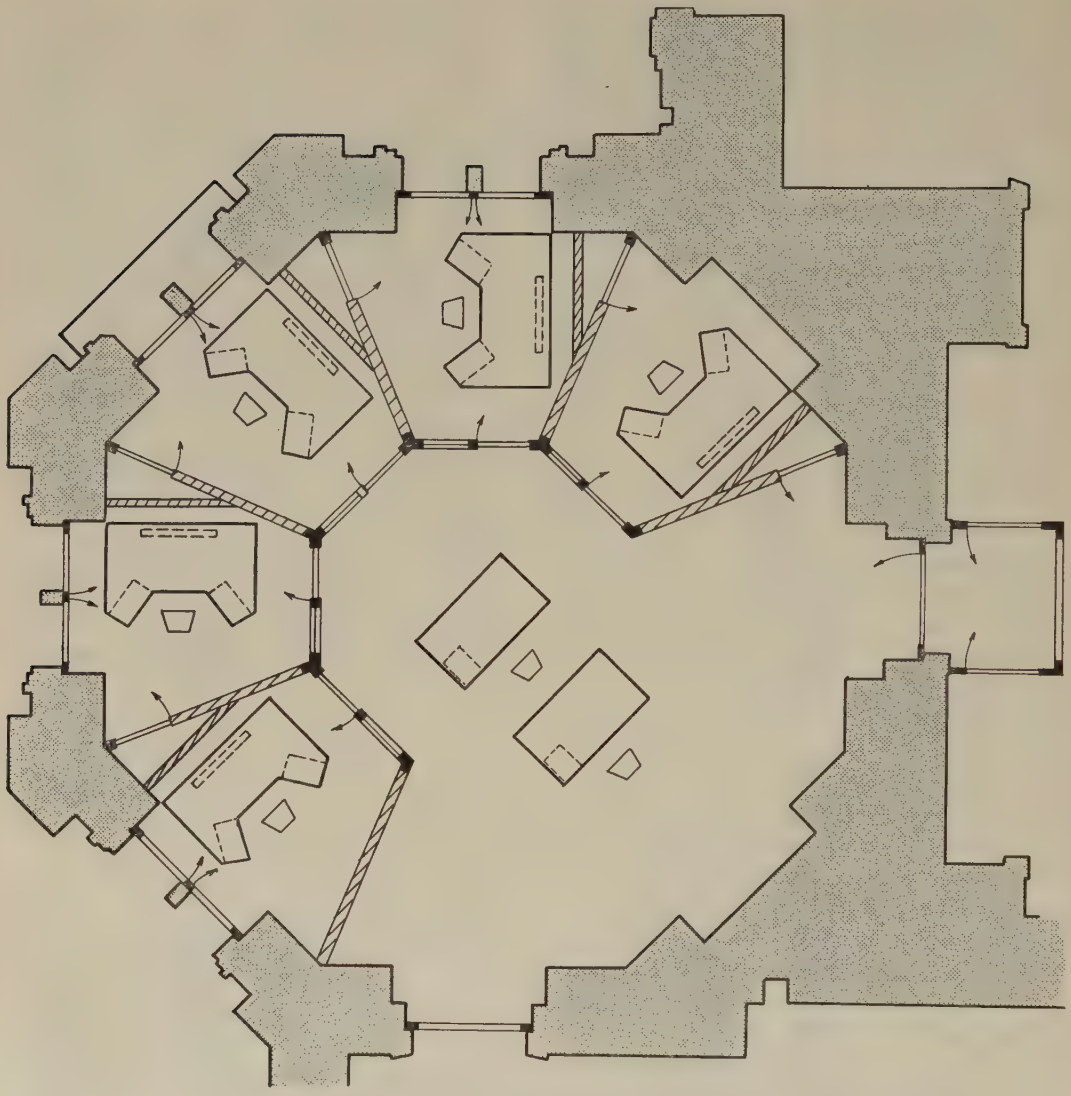


Fig. 17.

tube is connected through a high impedance (about 15 000 ohm) across the contacts of a relay to the line to be supervised. The line or lines to be supervised (for nothing prevents the simultaneous supervision of several lines) are switched in by keys arranged on the Chief Controller's desk. It may be noted that a two-wire connection is adequate if it is linked to the microphone circuit of the table,

because the information coming in from the way stations is retransmitted through the acoustic connection between loudspeaker and microphone with an attenuation of the order of 20 decibels (see above).

A light acoustic treatment has been applied to the room of the Chief Controller so as to give the regional centre a uniform general appearance.

Apart from the supervision by means of control loudspeaker the Chief Controller also disposes over communication channels of the way station type (i.e. four-wire high impedance lines) connected to each of the control circuits of the regional centre. These connections enable him to speak to all the way stations.

Similar connections of the way station type, linked to each control circuit of the regional centre, are also at the disposal of the Deputy Chief Controller who is more particularly concerned with the supervision of certain goods traffics (perishables, registered consignments etc.) or, in certain cases, with questions of train staff relief. This official is thus also in a position to intervene directly on all the lines concerned.

Finally, mention must be made of certain supplementary telephone installa-

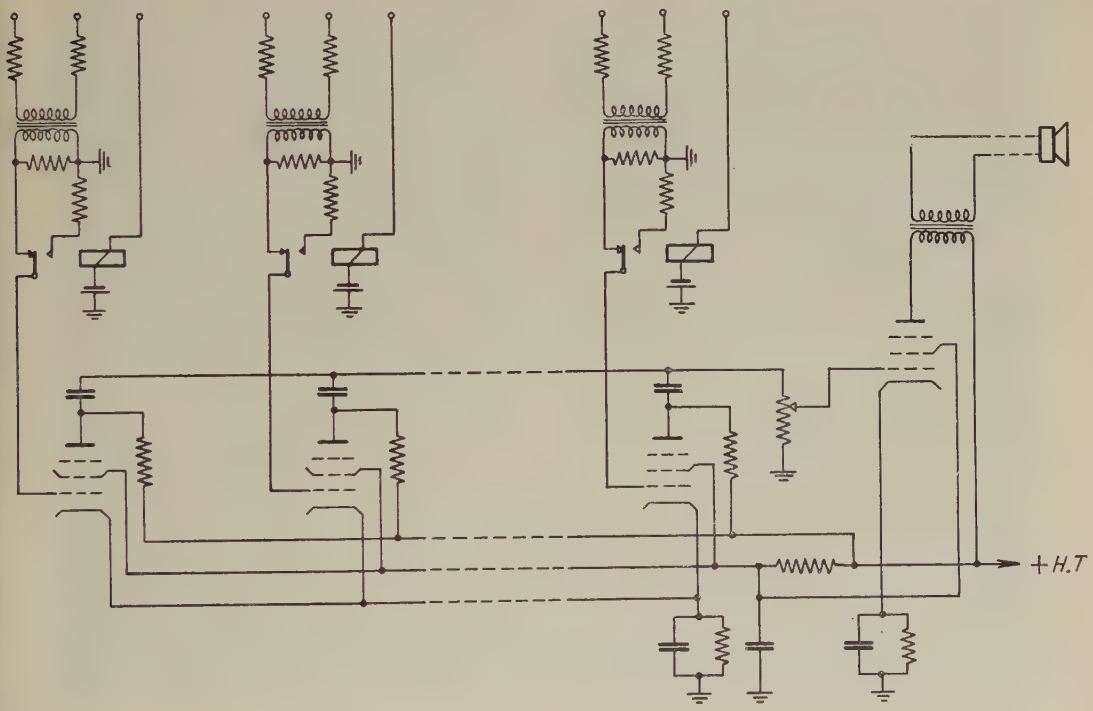


Fig. 18.

tions with which all the desks can be equipped :

— a connection to the automatic telephone network of the S.N.C.B.;

— one or two direct lines, with call by magneto type currents, with certain telephone stations placed at points with which special rapid communication channels are useful;

— transfer of a control circuit to another desk during hours of slack traffic (night-time, Sundays, etc.); this arrangement is known as « concentration »;

— in the case of electrified lines, direct connections with the officials in charge of substation load distribution and motive power allocation;

— equally in the case of electrified lines, connections with the emergency telephone lines which run alongside the tracks and which enable the operating staff to report difficulties in operation (or the maintenance teams responsible for the overhead traction equipment to demand the cutting out and restoration of traction current).

All the keys and call lamps concerned with these lines are grouped in the panel on the left hand side of the desks, below the micro-telephone (fig. 19).

The layout of the railway network may, in certain cases, call for the linking of certain control desks as ordinary way stations to the circuits emanating from remote regional centres. This type of connection is known as « end of line » connection.

5. Telephone way stations.

As explained in Part I of the present article, the way stations are always of the four-wire type with impedances of 600 ohm, no matter whether the main circuit is of the four-wire coil loaded type or is equipped with apparatus for the use of two frequency bands. It has, moreover, become obvious from the study of the loudspeaker equipment at the control office that an improvement of the characteristics of microphone and telephone cases would be desirable.

The way stations need only be connected to the circuit during conversations. At rest, the induction coils are therefore disconnected. Moreover, as the levels along the line may vary by about 13 decibels with the distance behind the last repeater, one has tried to obtain a certain equalisation by connecting an attenuator to the way station branch circuit. These attenuators are provided for values staggered from 2 to 2 decibels.

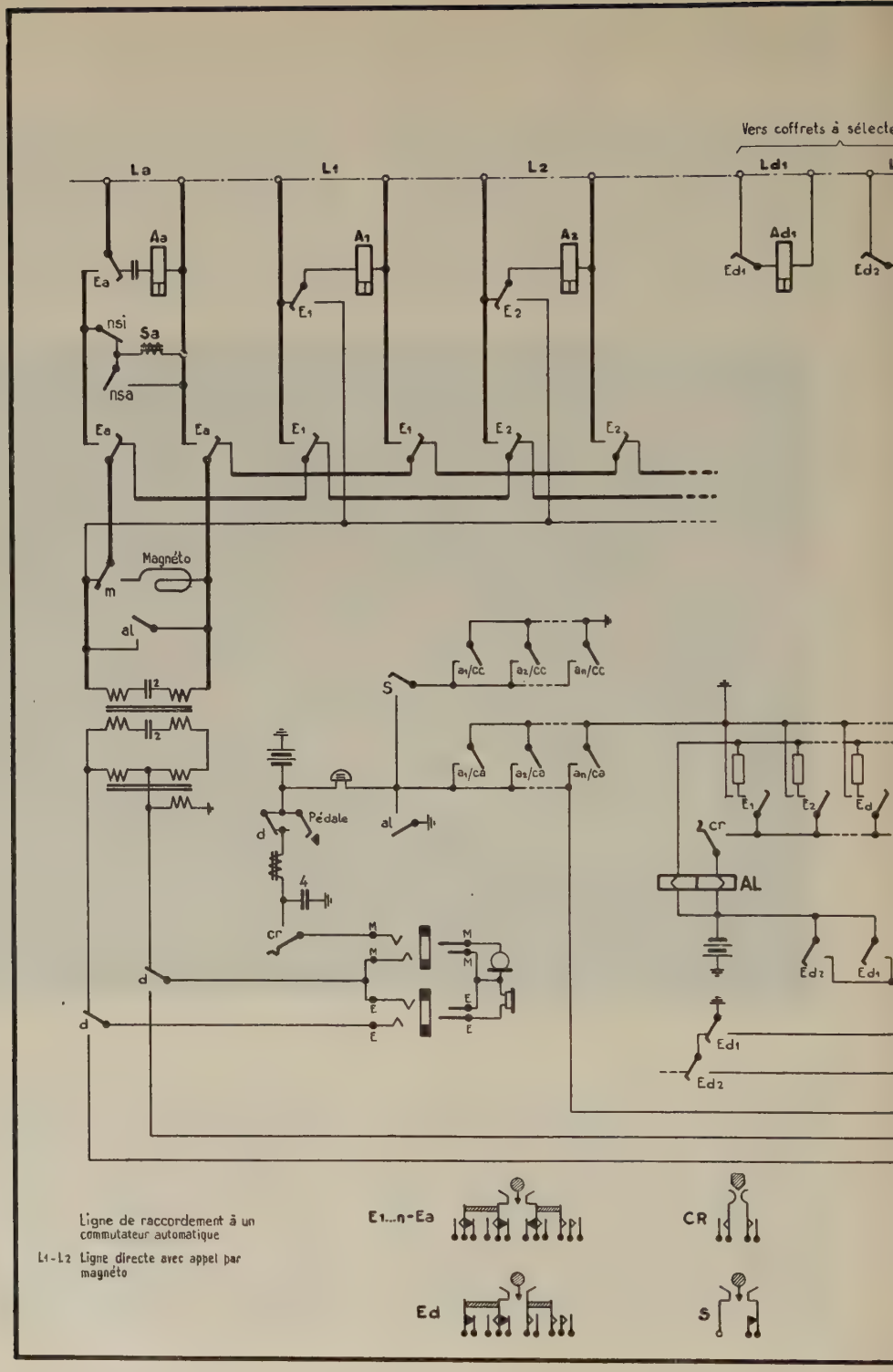
The telephone sets used are chosen in accordance with local circumstances; they may be wall mounted or desk mounted (simple, or combined for several directions). The desk mounted sets are arranged to form part of a small cabinet containing the selector and some relays, one of which serves to link the station to the line circuit through the attenuators mentioned above.

For economic reasons, frequent use if made of combined sets for several lines. Among these, one or two are control circuit connections, whilst the others are connections with stations or signal boxes in the neighbourhood, with telephones at signals, or even with the automatic telephone system. With minor installations, use is made of so-called

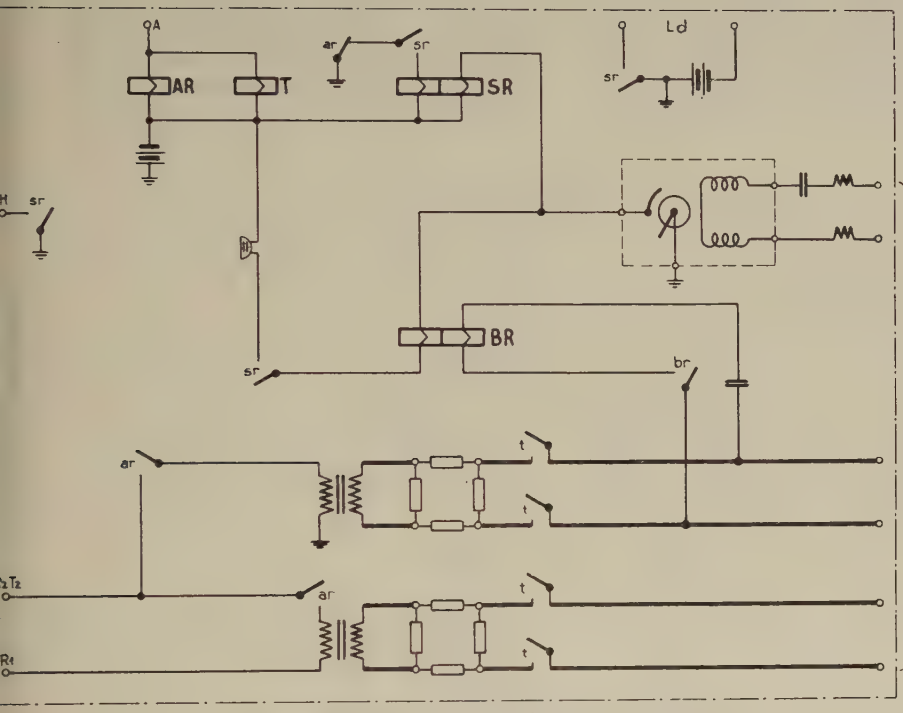
« key-boxes » (fig. 20) where each connection comprises a drop type indicator and a telephone key. The micro-telephone circuit is cascade-connected through the different keys; those allocated to control circuits control the relays of a selector box. The « key-boxes » as well as, incidentally, the way stations described earlier on are fed with 12 volt current.

In major installations, so-called « concentration stations » are used. These comprise one lamp and one key per line and the joint organs (microtelephone, two induction coils, a number dial, a buzzer etc.). It may be of interest to mention that the desk mounted set can be located a fairly long way away from the associated relay apparatus, which has led to the adoption of an arrangement whereby the number of wires connecting these two organs is greatly reduced. As will be seen from Figure 21, the necessary cabling comprises but a few joint wires and a single control wire for each line connected up, and this in spite of the fact that the line concerned may also be a connection to a control circuit of the four-wire type. At these stations, a current supply of 48 or 60 volt is used which may be shared, if necessary, with a local

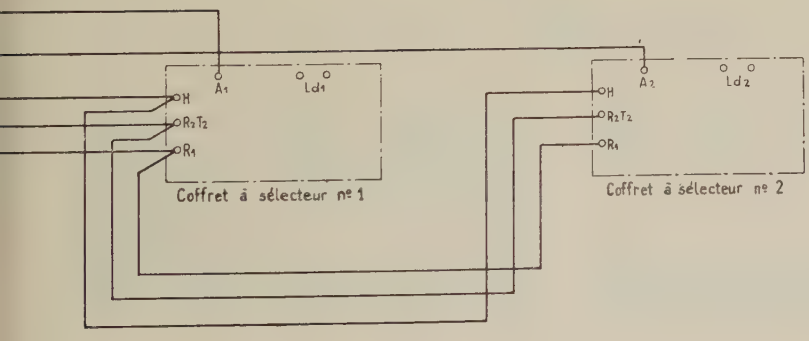
Fig. 19.



Coffret à sélecteur = selector cabinet. — Ligne de racc. à un commutateur automatique = Connection to auto



Détail d'un coffret à sélecteur



– L_1 — L_2 = direct line with magneto type call. — Raccordement suivant Fig. 3 = connection as shown in Fig. 3.

automatic telephone commutator. It would take too much space to describe, within the present article, the details of the various solutions adopted, and how they have been put into practice; such a description would be more directly concerned with another subject, viz. that of railway station telephones.

« voltage » counter-reaction which can be so adjusted as to provide a gain increasing in frequency so that it is well adapted to the attenuation/frequency curve of the corresponding section of the coil loaded cable. The maximum repeater gain that can be obtained is 3 N.

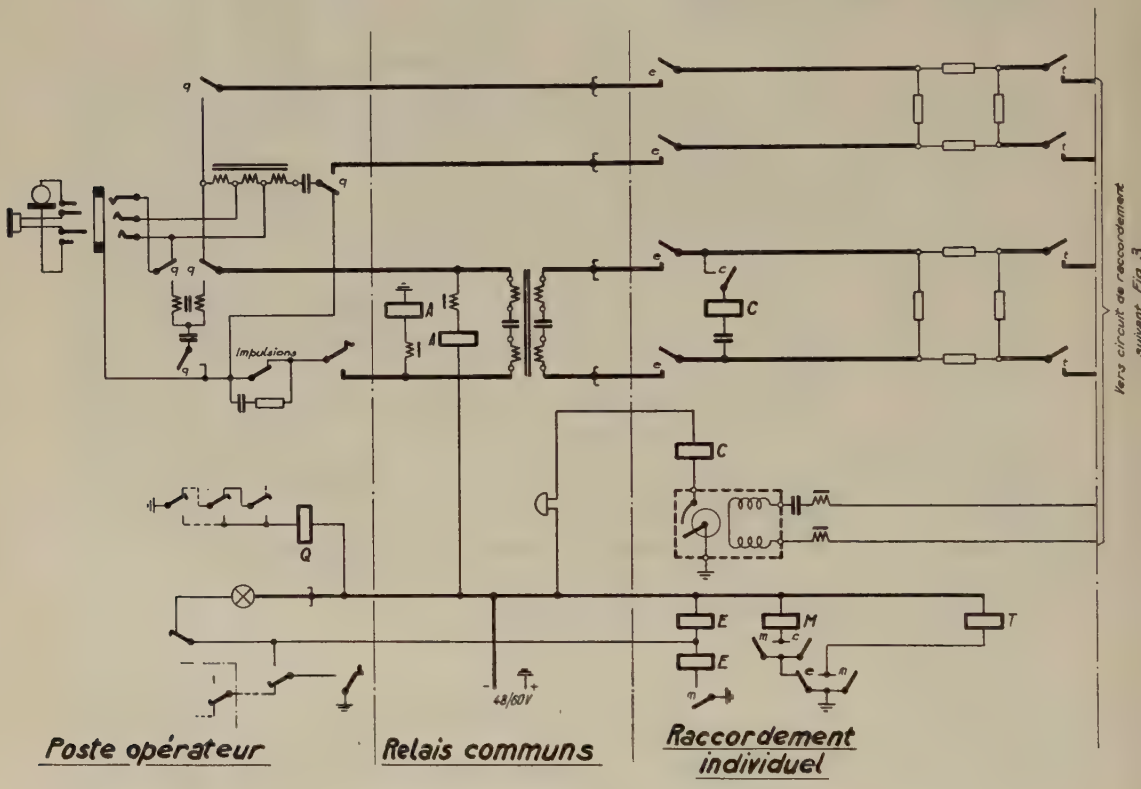


Fig. 21.

Poste opérateur = operating station. — Relais communs = joint relays. — Raccordement individuel = individual connection. Vers circuit de raccordement suivant Fig. 3 = to connection circuit as shown in Fig. 3.

6. Repeaters.

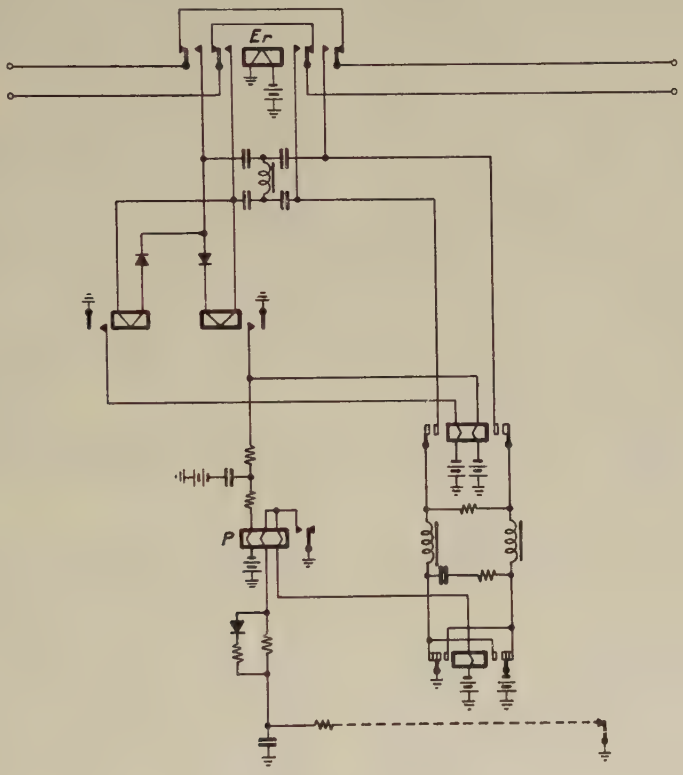
The repeaters connected to the circuits are of the ordinary four-wire type, with a single amplifier valve. They possess a

Connection diagram and structural arrangements are of the conventional type, except that the valves are indirectly heated by alternating current of the sector and that a permanent control device by electronic valve is used.

7. Impulse re-transmitters.

The voltage limits for the call current are determined, on the one hand, by the selectors (which require a minimum voltage of 57 volts) and, on the other hand, by the voltage that can conveniently be applied to the cables (about 100 to 110 volts). The limited range of the call voltages (see Part I, paragraph 3) therefore necessitates the use of re-transmitters or impulse re-generators.

It must also be pointed out that impulse re-transmitters are indispensable at the points where the structure of the transmission line changes (e.g. from overhead line to cable) as the circuits would otherwise become unbalanced and would therefore be liable to intercept outside noises (e.g. due to electric traction).



Impulse repeater

Fig. 22.

As shown in the basic connection diagram, Figure 22, these devices comprise a relay E*r* which is energized when connected to the voltage used for the re-transmission of impulses. When the voltage lapses, the relay drops and re-establishes the continuity of the line.

In this case, the impulses will obviously reach the selectors further down the line with an attenuated voltage, incurring the risk that the selectors may not react. However, the relays receiving the impulses in the re-transmitters are more sensitive than the selectors because a voltage of 30 to 35 volt is sufficient for them. In designing the circuit, the following particularities can be taken into account : If the feed of a given impulse repeater is not fully safeguarded, the following repeater will be placed at such a distance that it will receive impulses at a voltage of at least 35 volt if the first repeater fails to act. (This will, of course, only apply if there is no absolute need for the intermediate stations to be called by the controller, which will be the case if the main function of these stations is to transmit information to the controller about the running of trains, and not to receive instructions from him.)

Apart from the relay E*r* already referred to (and, in the case of a two-wire circuit, a high-pass filter), the re-transmitter comprises :

— a device for the retransmission of impulses, consisting of the two usual relays, one of them being a slow-acting relay with a filter designed to eliminate the harmonics of a higher order;

— an impulse correcting circuit which comprises a polarized relay (with permanent magnet) with two resistance devices and time-constant condensers which serve to fix the time of operation, in each direction, of the armature of the polarized relay (which is, in the rest position, situated midways between the two contacts);

— two relays designed to receive impulses transmitted from further down the line; these two relays are polarized with the aid of cells which react alternatively according to the polarity of the impulse received; both these relays act on the slow-speed relay governing the retransmission down the line, but only one of them controls the correcting circuit.

In practice, impulse correction is useful to smooth out the possible harmful effects of the capacities of long cable lines or of the filters of the two-frequency band devices. The values of the time constants are chosen so as to reproduce the normal frequency (3 1/2 cycles) at the normal supply voltage (100 to 110 volt).

8. Devices to connect or disconnect the lines.

Operating conditions on the railway require, from time to time, the exchange of information between controllers of different regional centres. If the circuits placed at their disposal meet at certain intermediate stations, it is not difficult to install, at those points, a device bringing about intercommunication between the circuits.

The study of the levels of the four-wire circuits, as outlined in paragraph 11 of Part I, leads to an equivalent of about 1 N between two opposed controllers' stations. For this purpose, it is necessary to disconnect the terminal resistances which may either be in the form of real circuit terminals (fig. 23) so as to avoid the formation of stationary waves (Part I,

paragraph 2), or in the form of resistances associated with the coupling networks (fig. 24).

If the circuit is designed in accordance with the two-frequency band technique, it is first necessary to resort to demodulation so as to obtain a four-wire circuit, with the two controllers' circuits which can enter into communication. A first transmission of the code on the part of one of the controllers concerned will bring about the connection, through operation of the relays, whilst a second transmission of the same code will cause the release

Fig. 23.

Ligne = line.

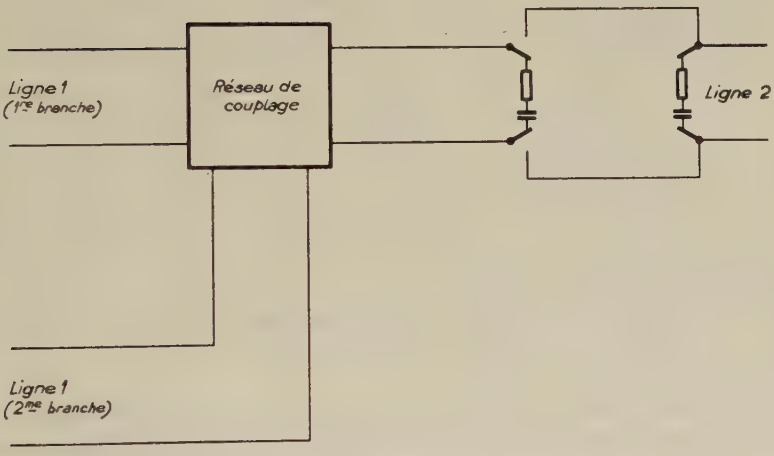


Fig. 24.

Ligne = line. — Réseau de couplage = coupling network.

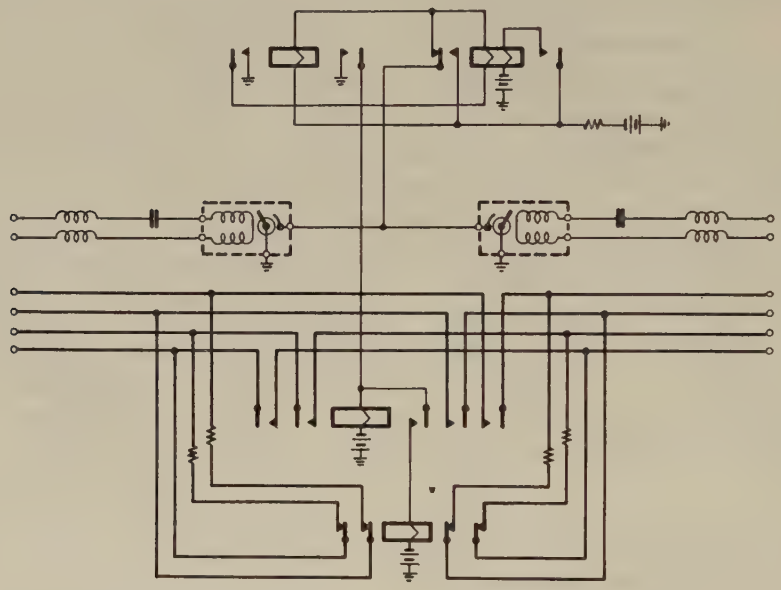
which leads to the same solution as in the preceding case.

The necessary apparatus thus comprises the terminal resistances which can be disconnected, and the connection-making relays. These are energized (fig. 25) by one or the other of the selectors associated of the relays and the disconnection of the lines.

The codes used will preferably comprise a number of impulses which is different from that used for calling the way stations (e.g. 19, if the normal code consists of 17 impulses) so that a general call or the

hourly transmission of the time signal do not bring about the interconnection.

It may be pointed out that the same apparatus also serves for another purpose, namely, the temporary disconnection of a section of line which has developed a fault, until the fault has been traced and repaired by the maintenance staff. In practice, such a case occurs with overhead lines.



Device to bring about intercommunication between two control circuits

Fig. 25.

9. Devices for the coupling or shunting of lines.

Owing to the complexity of railway networks, where the controllers are often called upon to coordinate the traffic on several branch lines, the control circuits must often be composed of different lines which must be interconnected similar case arises if it is necessary, during slack hours, to allocate several circuits to the same controller (temporary connection known as « concentration »).

These interconnections (see Part I, paragraph 5) which may affect the two circuits of a four-wire system, involve in most cases three branches, sometimes four. They are carried out according to one or the other of the following methods :

— star-connection of resistances (fig. 26 and 27), a method of connection which gives rise to comparatively high losses (6 decibels for three branches, and 9 decibels for four branches);

— connection by means of differential transformers (figs. 28 and 29) which give rise to smaller losses (3.5 decibels for three branches, including the internal losses of the transformers);

— connection through the grouping of resistances as advised by L. W. EAST *(loc. cit.)* (fig. 30).

It should also be remembered that, where it is necessary to go over from a four-wire

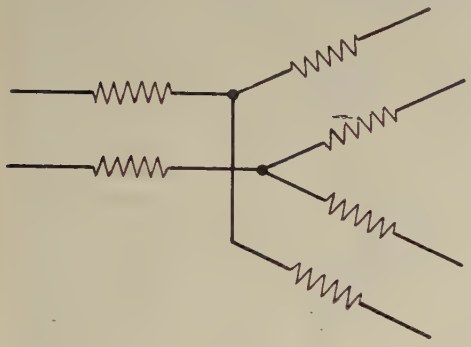


Fig. 26.

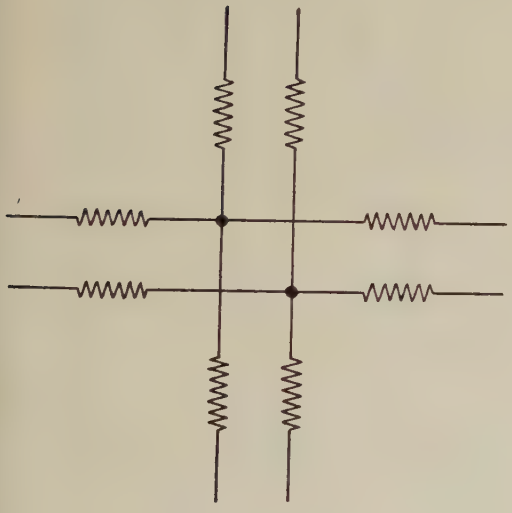


Fig. 27.

line to a two-wire line (e.g. for the overhead extension of a cabled four-wire circuit), use is made of a terminator (differential transformer with equilibrator). This arrangement can be adopted whether the controller is linked to the branch with the cabled four-way system, or to that with the overhead two-wire system (a case which may occur if an existing overhead line must be extended into an electrified zone with cables).

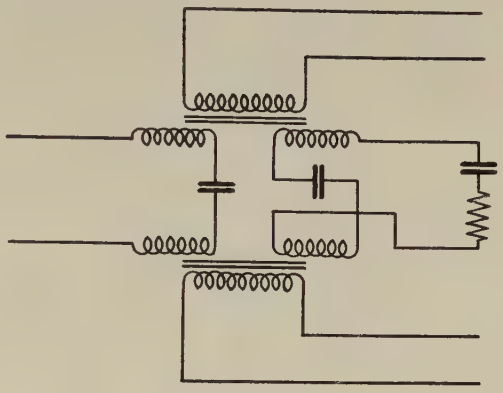


Fig. 28.

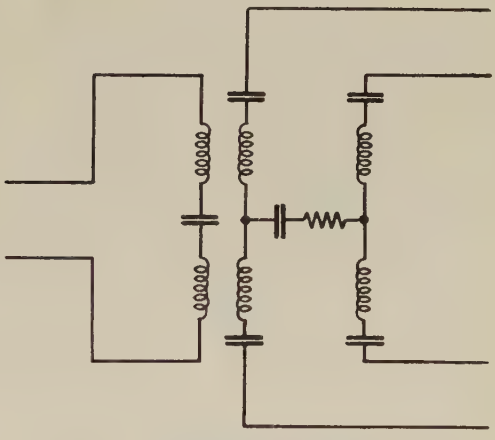


Fig. 29.

In the first of these two cases, the stability conditions of the working of the controller's loudspeaker station referred to above call for the realisation, at any voice frequency transmitted, of a high value of equilibrium attenuation. In spite of the use of high-pass filters in

the installation of the terminator, this condition imposes fairly stringent limitations on the overhead line section as regards its homogeneity (regularity of impedance) and attenuation (length).

All the specific situations hitherto encountered have been successfully met with the aid of these connection methods, used either separately or in combinations.

this cable was manufactured, it was possible to incorporate some supplementary circuits so that various tests could be carried out.

This test has permitted :

— to constitute a four-wire type circuit of great length (approx. 175 kilometres) by connecting several two-way circuits end to end;

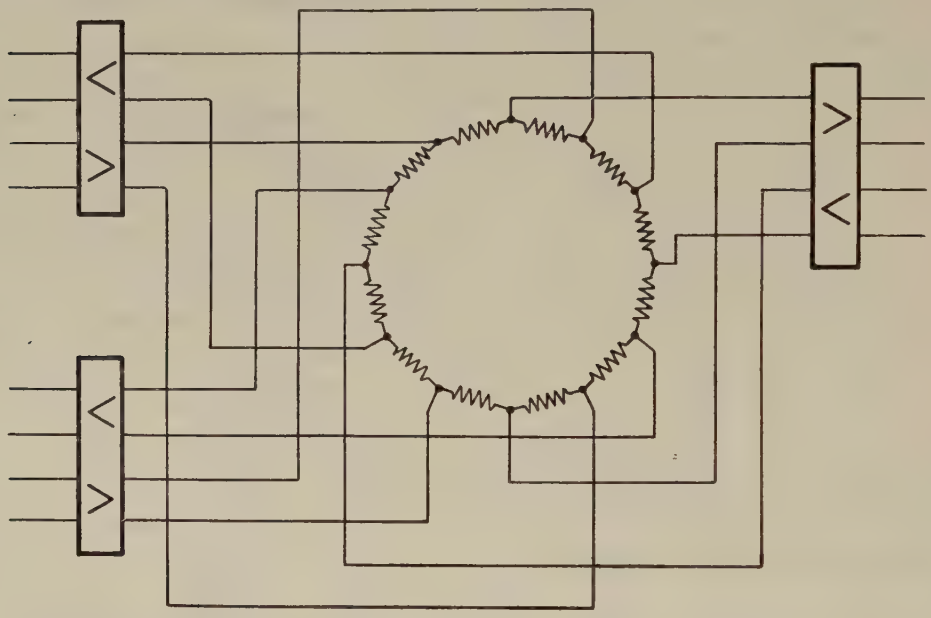


Fig. 30.

PART III

EXAMPLES OF ACTUAL CIRCUIT INSTALLATIONS.

1. Preliminary tests.

It has been possible to make good use of the early installation of a coil loaded cable in order to test, before taking it into operation, the soundness of the considerations outlined above. Moreover, when

— to carry out comparisons with different systems (two-wire and six-wire systems).

From a transmission point of view, these tests have shown that the four-wire and six-wire systems were practically equivalent as long as the working was confined to the use of a micro-telephone at the controller's office. In the case of a controller's office with loudspeaker

installation, the safety margin in respect of « singing » is hardly adequate for a six-wire system because of the two-wire passage in the pilot circuit, and in spite of extensive research concerning the optimum equilibrium, it has not been possible to obtain sufficiently stable operation. In contrast, the only causes of singing noises in the four-wire system were found to be the parasitic connections between the « microphone » and the « telephone » pairs of wires. The tests showed that the dominating effect was that of the magnetic coupling between the induction coils of the microphones and telephones of the way stations. By arranging these coils at right angles in relation to each other, the coupling effect was reduced to the values shown in paragraph 10 of Part I. After that modification, the four-wire system clearly proved to be more stable than the six-wire system, and has since been standardized throughout, except for the very short and non-amplified circuits where the two-wire is adequate.

It may be pointed out that all the figures quoted in paragraph 10 of Part I, and especially the curves of Figure 6, emanate from measurements carried out during these preliminary tests. Later on, the values derived from these tests have been used systematically for the planning of the equivalents in the most complicated circuits, and the equivalents thus calculated were always confirmed by the measurements with sufficient agreement. It must be regarded as a further advantage of the four-wire system compared with the six-wire system that it permits the forecasting of the equivalents with an accuracy comparable to that of inner-urban circuits in ordinary telephony.

2. Examples of circuits installed.

The operating conditions of the Belgian railway system frequently call for the establishment of control circuits comprising several branch lines which are sometimes situated at a comparatively great distance from the control office. Also, in several instances, the circuits include cable sections as well as open line sections.

A. *Simple circuit without branches, of uniform composition.*

Figure 31 shows the connection diagram of the Charleroi-Brussels circuit which has an overall length of 100 km and comprises 68 way stations. This circuit contains the various elements described above :

1. a telephone station with microphone and loudspeaker for the controller, with associated amplifier;
2. the connection of the emergency micro-telephone, for use in the case of a breakdown at the loudspeaker equipment;
3. a branch circuit to the supervision amplifier of the Chief Controller;
4. the « concentration » connection with another circuit at Charleroi control office;
5. a four-wire repeater, terminal type;
6. an impulse transmitter of the key-board type, connected to the mid-points of the repeater coils placed at the starting point of the circuit;
7. the various way stations;
8. two intermediate repeaters;
9. four impulse re-transmitters;
10. a device for temporary communication with another control circuit, combined with a three-branch connection system.

Attention may also be drawn to the terminal resistances (at Schaerbeek-Josaphat) which have the purpose of preventing the production of stationary waves (see Part I, paragraph 2).

B. *Cabled circuit with multiple branches.*

Figure 32 shows the diagram of a so-called « combination » circuit which contains a comparatively small number of way stations (all of them located at points of importance for wagon load traffic) which are, however, distributed over numerous branches of the circuit.

This diagram can serve as an example for the use of some of the devices that can be employed for providing branch connections. Each of the branches is treated as a transmission line which is, incidentally, equipped with terminal resistances.

C. *Mixed circuit, mainly in cable but with open line extension.*

The special feature of this circuit (fig. 33) is a short extension (« feeler ») along a non-electrified line so as to permit the connection of two stations. This branch is connected to the main circuit by means of a terminator (with filter), a cut-off device and an impulse re-transmitter.

D. *Open line circuit with cabled extension.*

This simple case is shown in Figure 34. Note the impulse re-transmitter (transition between open line and underground line) and the terminator fitted with an omnibus equilibrator.

E. *Mixed circuit with underground cable sections and open line sections, using the two-frequency band system.*

The diagram shown in Figure 35 relates to a particularly complex circuit which comprises sections of coil loaded cables (alongside electrified lines) as well as open line sections (because the railway lines concerned are not included in the electrification programme). The use of underground cables along the electrified sections of line is unavoidable because :

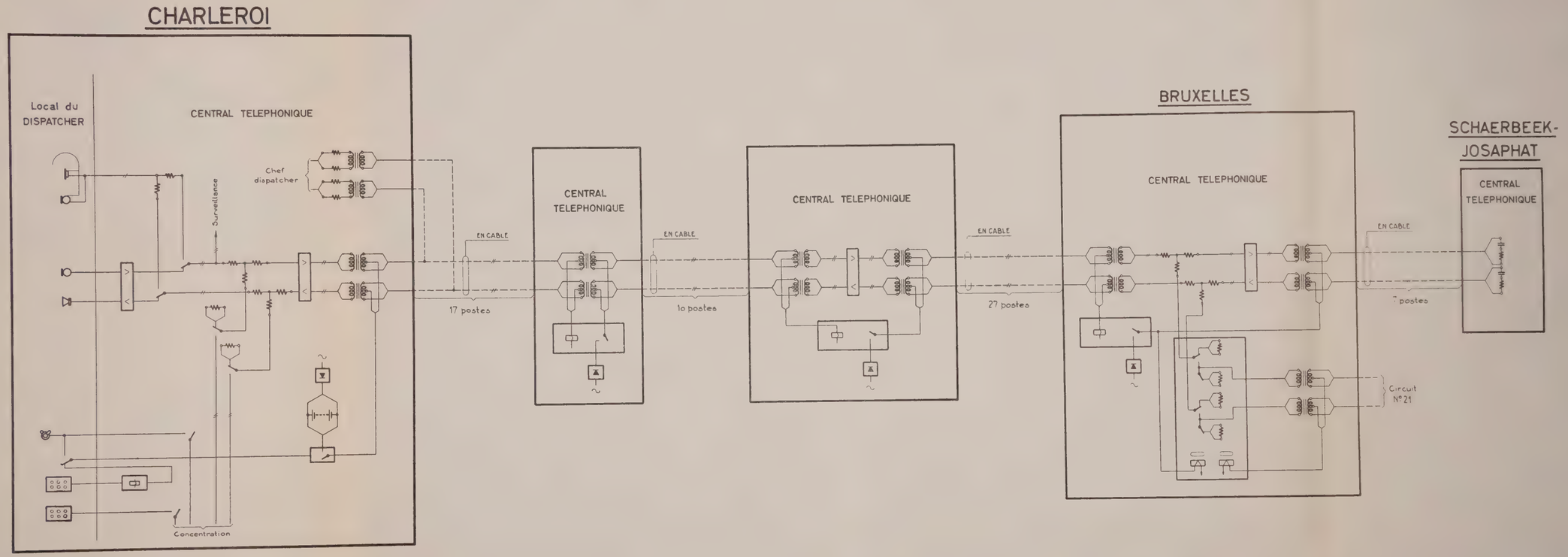
— this is the only effective means of avoiding induction noises caused by the harmonics of the mercury vapour rectifiers (2 000 volt D.C.) used for the feeding of the catenary;

— the overhead lines would, in the case of short-circuits or other incidents on the catenary line, be liable to receive dangerous voltages so that they might either give rise to acoustic shocks in the telephone sets connected to the circuit or even endanger the personnel in contact with the lines;

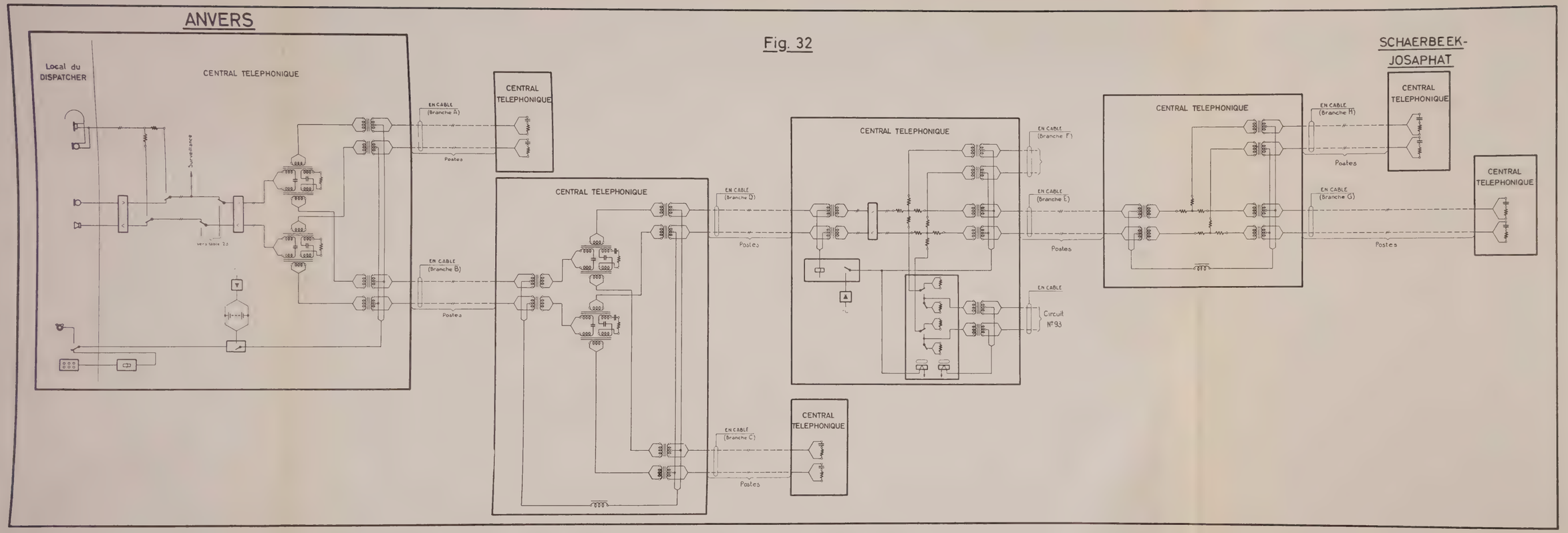
— this solution is not less economic than the shifting of the existing open lines (which would have necessitated the purchase of land outside the property at present owned by the railway), having regard to the installation of the supplementary circuits required in consequence of the electrification.

These reasons do not apply to non-electrified lines so that the control circuits along those lines have been preserved as overhead lines. Nevertheless, it is necessary to ensure effective telephone transmission, to and from the way stations as well as to and from adjacent control circuits. These conditions can be met without difficulty by using the two-frequency band technique. It is no great encumbrance to use two repeaters as these devices require little intervention on the part of the maintenance staff; moreover,

Fig. 31

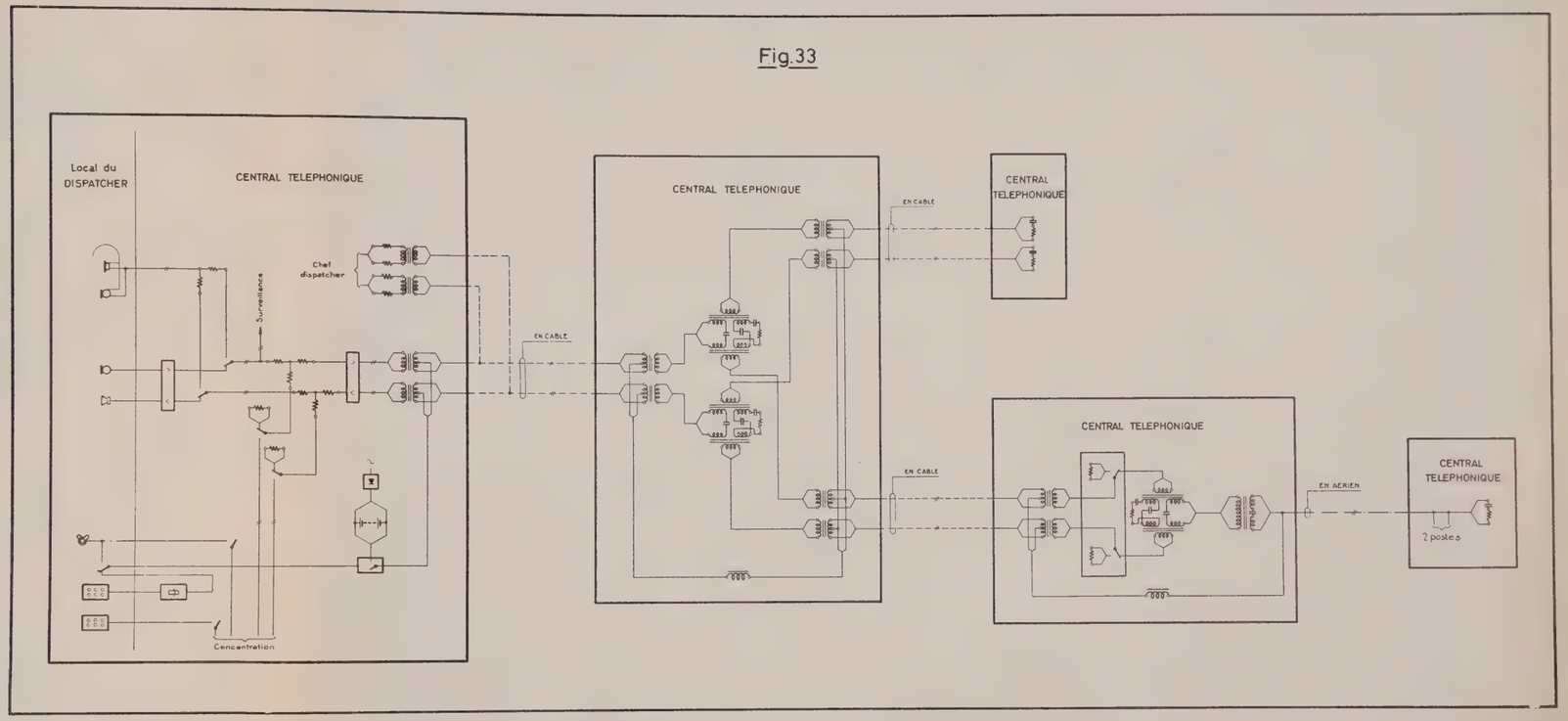


Local du dispatcher = control office. — Chef dispatcher = Chief controller. — Central Téléphonique = telephone switchboard. — Postes = way stations.



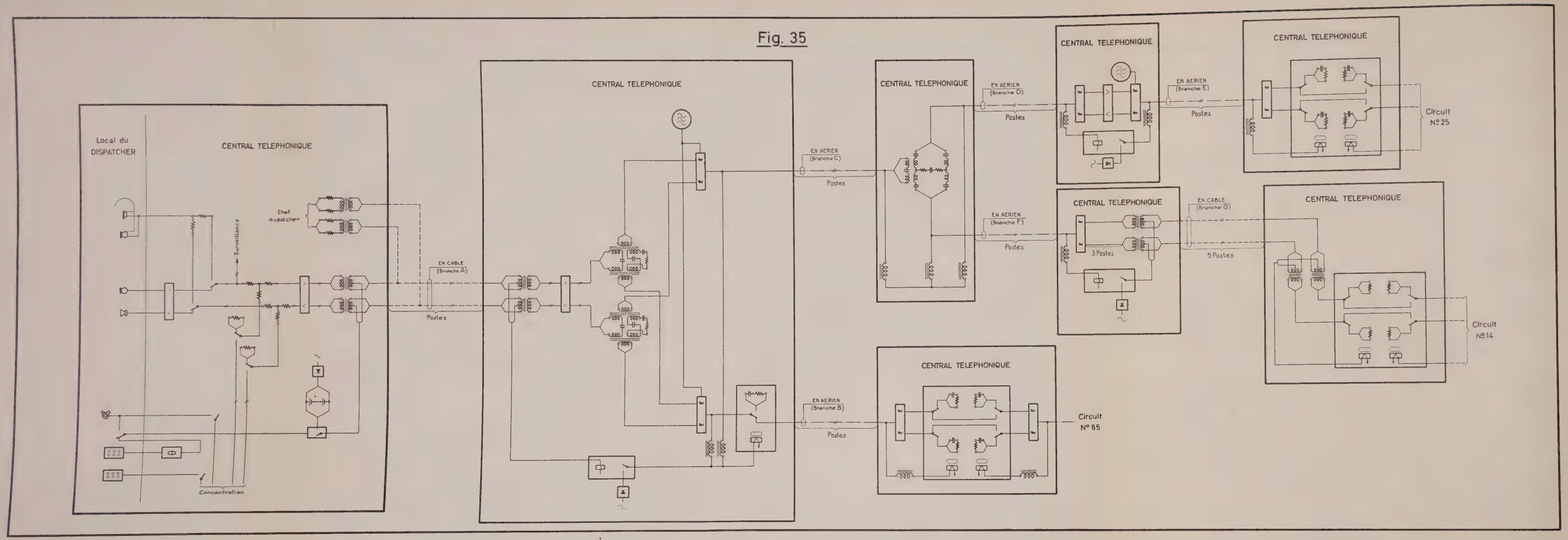
Local du dispatcher = control office. — Chef dispatcher = Chief controller. — Central Téléphonique = telephone switchboard. — Postes = way stations.

Fig.33

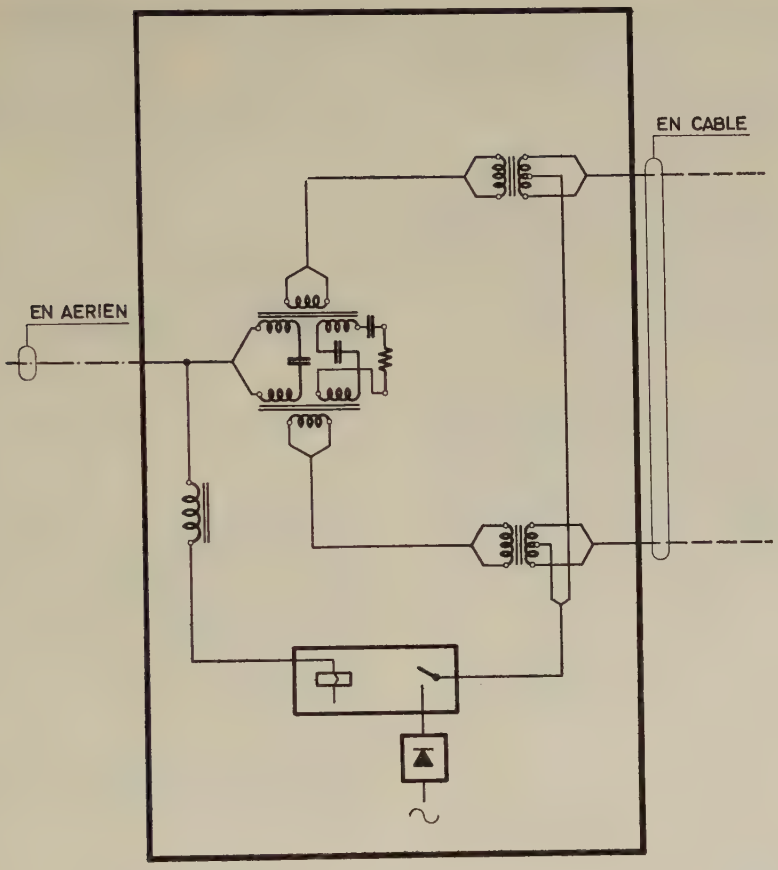


Local du dispatcher = control office. — Chef dispatcher = Chief controller. — Central Téléphonique = telephone switchboard. — Postes = way stations.

Fig. 35



Local du dispatcher = control office. — Chef dispatcher = Chief controller. — Central Téléphonique = telephone switchboard. — Postes = way stations.



Four-wire extension of a line which is of the overhead type over most of its length.
Fig. 34.

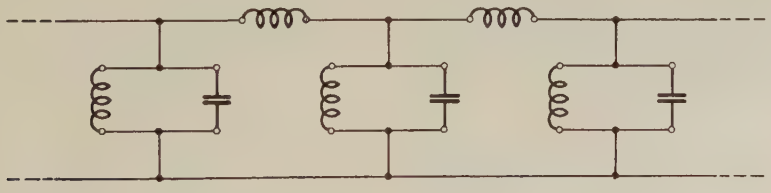


Fig. 36.

they are placed in the same premises as the minor automatic telephone exchanges so that they can be easily supervised.

Attention may be drawn, among the various means used for the interconnection of the lines, to the terminal device (hexa-

pole) used at the junction of two overhead lines. This device has been adopted because of the small losses (maximum 0.4 N) introduced by it.

* * *

In concluding this article, the authors wish to thank all their colleagues who have taken part in the installation work, in the sometimes wearisome tests, and in the perfection of the techniques here outlined.

They would also like to emphasize the excellent cooperation between the S.N.C.B. and the Bell Telephone Manufacturing Company during the discussions and installation work. Finally, they wish to express their sincere thanks to the responsible S.N.C.B. authorities for the permission to publish the present article.

Brussels, 10th June, 1955.

APPENDIX A

Calculation of the optimum impedance of stations.

a) *Terminal line.*

If the line is terminated on an impedance W and used by a source adapted to W and with an *e.m.f.* of 2V, the line voltage at a distance D is :

$$V e^{-\alpha D}$$

and the energy received at the last station is :

$$(V e^{-\alpha D})^2 / R$$

If this energy is compared with the one of V^2/W which would be discharged at a suitable receiver directly connected to the source, it will be seen that the attenuation between the source and the last receiver amounts to :

$$A = \frac{1}{2} \log_e \frac{V^2/W}{V^2 \, e \exp(-2\alpha D/R)} = \alpha D + \frac{1}{2} \log_e \frac{R}{W} \qquad (14)$$

However, according to (3) and (2), the attenuation of the line is :

$$\alpha D = rD/2W + nW/2R = A_o + nW/2R \qquad (15)$$

hence :

$$A = A_o + nW/2R + \frac{1}{2} \log_e \frac{R}{W} \qquad (16)$$

This attenuation consists of that of the line proper (A_o), of n times the branch circuit effect W/2R, and of a last term due to lack of adjustment. Equation (16) is a function of the variable R/W; its minimum is found through differentiation which yields equation (4). This value, carried into equation (16), yields equation (5).

b) *Open line.*

In this case, the voltage at the end is V/ch αD, and equation (14) is replaced by :

$$A = \log_e \operatorname{ch} \alpha D + \frac{1}{2} \log_e \frac{R}{W} \qquad (17)$$

The gain of 0.35 N compared with (16) is obtained, for long lines, with the aid of the approximation :

$$\operatorname{ch} \alpha D \overset{\sim}{=} \frac{1}{2} e^{-\alpha D} .$$

c) *Case of variable impedance.*

In the case where the impedance R (x) of the stations varies as a function of x (distance from the origin), the number of stations over an interval dx is rdx/D, and the shunt effect, corresponding to the second term of equation (16), over the interval dx is $nWdx/2R\,(x)\,D$.

The attenuation $A(x)$ between the origin and the station situated at x will be :

$$A(x) = \frac{A_o x}{D} + \frac{nW}{2D}\int_o^x \frac{dx}{R(x)} + \frac{1}{2}\log_e \frac{R(x)}{W} \qquad (18)$$

The best impedance variation of the stations is obtained when the attenuation is independent of x, i.e. when the differential of (10) in respect of x is zero :

$$A_o/D + nW/2DR(x) + R'(x)/2R(x) = 0 \qquad (19)$$

This condition is a linear differential equation of the first order for $R(x)$. Its solution, with an arbitrary constant C, is :

$$R(x) = -nW/2A_o + Ce^{-2A_o x/D} \qquad (20)$$

C must obviously be positive and greater than the first term of (20). The resistance decreases when x increases and becomes negative from a certain value. C must be so chosen that, for $x = D$, R (D) is still positive. As $A(x)$ is constant, its value for $x = 0$ can be calculated :

$$A = \frac{1}{2}\log_e (C/W - n/2A_o) \qquad (21)$$

By eliminating C between (21) and R(D) taken from (20), one obtains :

$$A = \frac{1}{2}\log_e \left[(e^{2A_o} - 1)n/2A_o + e^{2A_o}R(D)/W\right]$$

In this equation, R(D) is still unkown, and to obtain the smallest possible attenuation, R(D) must be given the smallest possible value. In the extreme (and in practice absurd) case of $R(D) = 0$, the attenuation amounts to :

$$A = \frac{1}{2}\log_e(e^{2A_o} - 1)/2A_o + \frac{1}{2}\log_e n \qquad (22)$$

For small values of A_o (keeping the first three terms of the MacLaurin development of the exponential), one obtains :

$$A = \frac{1}{2}A_o + \frac{1}{2}\log_e n$$

Compared with equation (5), one obtains, in this case, a gain of 0.5 N plus half the attenuation of the line proper. It must however not be forgotten that the assumption $R(D) = 0$ yields too low a value of the attenuation. In fact, R(D) must remain great in relation to W for the calculation to be approximately correct.

APPENDIX B

Calculation of the attenuation of the call voltages.

The D.C. attenuation of the line amounts to :

$$\alpha = \sqrt{rg} = \sqrt{\frac{rn}{R\ D}} \qquad (23)$$

and the total attenuation is :

$$\alpha D = \sqrt{rDn/R} = \sqrt{r_t/R_t} \qquad (24)$$

where r_t is the total series resistance of the line and R_t the combined parallel impedance of the receivers. Equation (6) is obtained immediately from the conventional theory of propagation on an open line.

By eliminating V_D between (6) and (7), one obtains :

$$V = \sqrt{RP}\ \mathrm{ch}\ \sqrt{rnD/R} \simeq \frac{1}{2}\sqrt{RP}\ e^{\sqrt{rnD/R}} \qquad (25)$$

(approximation for high attenuations). Condition (8) is obtained by reducing to zero the differential of (25) in respect of R, whilst equation (9) is obtained by carrying (8) into (25). It may furthermore be noted that equation (9) can also be written :

$$V^2/r_t = 1.85\ nP \qquad (26)$$

linking the energy absorbed by the total series resistance of the line with the total energy required at the receivers.

For small attenuations, the approximation introduced in equation (25) is replaced by :

$$V = \sqrt{RP}\ (1 + nD/2R)$$

and the minimum, obtained for

$$R = nD/2 \qquad (27)$$

instead of (8), amounts to :

$$V = 1.41\ \sqrt{PnD} \qquad (28)$$

which differs but little from equation (9).

APPENDIX C

Calculation of the low frequency cut-off effect.

Taking into account the inductance of the repeaters, the shunt admittance of the line becomes :

$$\frac{n}{D}\left(\frac{1}{R} + \frac{1}{jwL_p}\right) + Cjw$$

and it will be seen that the effect of L_p is to replace Cjw by :

$$n/DL_pjw + Cjw$$

or to replace C by :

$$C(1 - f_o^2/f^2)$$

where f_o is given through equation (10). By carrying out this replacement in equation (3) and repeating the calculations which lead from (3) to (5), one finds equation (11).

It may be noted that the classic theory of filters, much in the same way as equation (10), well illustrates the lower cut-off frequency as an antiresonance of the shunt arms of the iterative structure of Figure 36.

For the upper cut-off frequency, the theory of the frequency band filter of Figure 36 yields a slight difference compared with the theory of the low frequency filter (coil loaded line without branches), but this difference is negligible for filters with great relative width of the frequency band.

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[625 .25 (09 (43)]

The fifty years of the KNORR-BREMSE Company,

by A. Brill, Dipl. Ing.,

Ministerialdirektor, Direktor der Hauptverwaltung der Deutschen Bundesbahn.

At the time of its foundation in Berlin, on the 19th. January, 1905, the Knorr-Bremse undertaking was devoted entirely to the manufacture and improvement of brake equipment for main line railways; European railways were still under the influence of the dynamic changes of the times which were manifested by what has been called the « new rhythm », including the birth of electric traction, speed trials with steam locomotives and electric motor coaches, complicated train announcing and telecommunications systems.

The history of the Knorr brake begins with the two-chamber brake designed by J. F. Carpenter between 1877 and 1879. This Carpenter compressed air brake was tried on trains in normal service between October, 1881 and April, 1882, i.e. more than 70 years ago, on the Berlin-Breslau line of the Prussian State Railways. These trials included tests in normal service. The favourable results obtained in these extended tests led in 1883 to the conclusion of a supply contract between the Prussian State Railways and the J. F. Carpenter Brake Manufacturing Company, having a period of validity of ten years.

The historic Guntershausen trials (1877) with compressed air, vacuum and mechanical brakes concluded, as we know, without any definite decision in favour of any particular type of brake, but for the first time in European Railway history it was recognised that the geographical characteristics of a country considered as a whole from the operating point of view were conclusively in favour of the application of the compressed air brake. The German railway system, geographically located in the centre of Europe, with numerous points of exchange with other countries' railway systems, was subject to numerous changes. In 1909, therefore, the « Berne programme », which was charged with the consideration of European brake design, included a project for a system guaranteeing efficient operation, as far as possible *uniform*, with an international train of any composition, whatsoever the combination of brake equipment might be.

About the middle of 1884, J. F. Carpenter discovered a young engineer, Georg Knorr, a man who possessed the necessary ability and energy to overcome the many problems which would be encountered and would have to be overcome by the firm.

The inconvenience of brakes with two chambers and the favourable results and experiences obtained with the single chamber brake in Southern Germany, and even more in America, attracted increasing attention in Prussia to this type of equipment. The firm of J. F. Carpenter, which in 1890 became « Carpenter & Schulze », devoted particular attention to these new developments and after

several tentative efforts which were not satisfactory, Georg Knorr finally succeeded at the beginning of 1 900 in producing a quick-acting single-chamber brake which was fitted by the Prusso-Hessian Railways to their passenger carriages contemporaneously with the Westinghouse Brake.

The problem of producing a freight train brake which would meet the needs of European railways was set by the « Verein Deutscher Eisenbahnverwaltungen » (Association of German Railway Managements) about 1903, and immediately provoked a lively interest in Georg Knorr, who had become the proprietor of the Carpenter and Schulze Works in 1893. The works retained their name until 1905, when they were changed to the *Knorr-Bremse GmbH*, and in 1907 Johannes Vielmetter became the commercial director. The firm then was mainly interested in the development of a continuous brake which would be suitable for freight trains. It was logical to start by using for freight trains the single-chamber passenger-type brake, which had in the meantime become fairly widespread. This line was followed with varying success until 1911.

An amalgamation then took place between « Continentale Bremsen GmbH » and the « Knorr-Bremse GmbH », resulting in the foundation of the Knorr-Bremse AG. of Berlin. The former director of the « Continentale Bremsen GmbH », Wilhelm Hildebrand, took over the technical direction of the new company's operations. The amalgamation allowed the manufacture of brake equipment for main line and local railways as well as tramways to be concentrated in a single undertaking.

Nevertheless, priority was given to the technical problem of producing a unified brake for freight trains as suggested in 1911 by the « Regierungs- und Baurat Bruno Kunze », and a design suitable for use in service was introduced in 1916. This equipment, known as the Kunze-Knorr brake, was followed by a similar arrangement for ordinary and express passenger trains and after the end of the first World War, it was adopted generally by the newly-formed German Reichsbahn. It was the first compressed air brake for freight trains with controlled brake effort, suitable for operating conditions on main line railways.

Its application to the rolling stock took about nine years and was completed in 1927. Its principal advantage was not only the controlled release which provided it with all the advantages of two-chamber compressed-air and vacuum brakes without incurring their disadvantages, but also the possibility, by means of a second brake cylinder, of braking loaded wagons more heavily than empty ones. Furthermore, the speed of freight trains could thus be considerably increased.

Under the direction of the International Union of Railways, important trials were carried out in 1926 in Northern Italy and on the St. Gotthard line to investigate the capabilities of the Kunze-Knorr adjustable and Westinghouse non-adjustable brakes. It was reported that the two brakes operated favourably in the trains and were suitable for international traffic. The tests however also provided a basis for the establishment of the Berne programme of the Technical Working (Unité Technique); they led to the formation of the well-known 33 rules to which all

new types of freight train brakes tested in future had to conform if they were to be approved for international traffic.

The application in 1927 by W. Hildebrand of a new brake system for express and freight trains achieved the desired standard of success and the international introduction in 1931 and 1933 of the « Hildebrand-Knorr » brake for freight trains was warmly welcomed by engineers in many countries.

The controlled brake effort of the Kunze-Knorr brake was obtained by means of a supplementary cylinder with two chambers, which admittedly operated only in the « loaded » position and in the final stage; in all other cases it served only as a distributor and for this purpose was a very heavy piece of equipment.

The Hildebrand-Knorr brake obtained its variation by means of a control valve depending on three pressures which gave it much greater precision with a considerably reduced weight. In addition, the Kunze-Knorr brake, because of its fixed ratio between the two piston areas was not especially superior except for a determined ratio between empty and loaded weights. By means of a variation in the multiplication ratio of the rigging, the Hildebrand-Knorr brake could apply a brake effort suitable for all conditions of loading. In addition to the more important advantages of the Kunze-Knorr brake, the new equipment had an increased operating speed, a reduced time-lag in release of the brake on a complete train and a very low rate of loss. As with the Kunze-Knorr brake, the Hildebrand-Knorr brake was also adopted by numerous European and non-European countries.

The brake equipment designed for ordinary passenger and express trains and for railcars was based on the same principle as the Hildebrand-Knorr freight train brake. The possibilities of adapting the Hildebrand-Knorr brake were great and could be more economically obtained by the addition or omission of components of the basic control valve, which was the same in all applications. This was probably the outstanding advantage over the Kunze-Knorr brake which, for each purpose, required specially-designed brake cylinders and control valves and so was more expensive in maintenance and replacement of parts.

The second World War naturally hindered the work of improving brake design, although the Knorr-Bremse Co. and the Reichsbahn did not completely abandon it. The loss of workshop capacity did not prevent the work being energetically resumed after the war from the point which had been reached earlier. The experience gained and the technical ability which was retained led to a very rapid resumption of the work.

At a time when it required great courage, from a financial point of view, to hold expensive basic production capacity and material out of production, the Knorr-Bremse Co. set up at Munich a large workshop and test equipment. Thanks to this, the work was pursued and concentrated in 1950 on the present « KE » brake system.

The new Knorr control valve has no pistons or segmental packings. These are replaced by diaphragms of buna rubber. The slide valves, whose operation was hindered by friction and entailed regular maintenance, are replaced by rubber-mounted valves, free from friction and highly sensitive. Moreover, there are no

ground and fitted parts; there are, in fact, no conically-seated valves which are difficult to grind. Maintenance demands are thus reduced to a minimum.

The new control valve of the « KE » brake can, by the addition of components, be adapted with the greatest ease for all purposes from the simple railcar valve to a complete train valve, with brake forces suitable to the type of train and automatic braking according to load. A single type of relay valve is used with all sizes of brake cylinder, without alteration to the brake application, release and refilling pipes.

The results of the tests undertaken with the KE brake valve system in the presence of the International Union of Railways' Brake Sub-Committee on the 14th-27th June, 1953, are well-known. The KE system answers completely to the 20 new regulations of the International Union of Railways, brought into force after revision of the 33 and 29 conditions applicable to freight and passenger trains respectively in 1951.

In addition to designing complete brake systems, the Knorr-Bremse Co. has also occupied itself with the improvement of various components and has introduced completely new ideas. This is the case with auto-control brake valves which considerably facilitate the work of the driver in operating the brake. For high-speed trains there are new controllers which vary the brake pressure in accordance with the speed. Anti-slipping devices protect the wheels against the formation of flats on the tyres. To conclude we may also mention their light-weight steel cylinders, compressors, pumps, magnetic rail brakes and electrically-operated brakes.

To celebrate the 50 years of its existence, the Knorr-Bremse Co. has just published a large and well-produced brochure which illustrates in a lively manner the evolution of railway brake equipment and the Knorr-Bremse Company's development and strikingly illustrates the results obtained in this field as a consequence of unceasing work.

[621 .438 (73)]

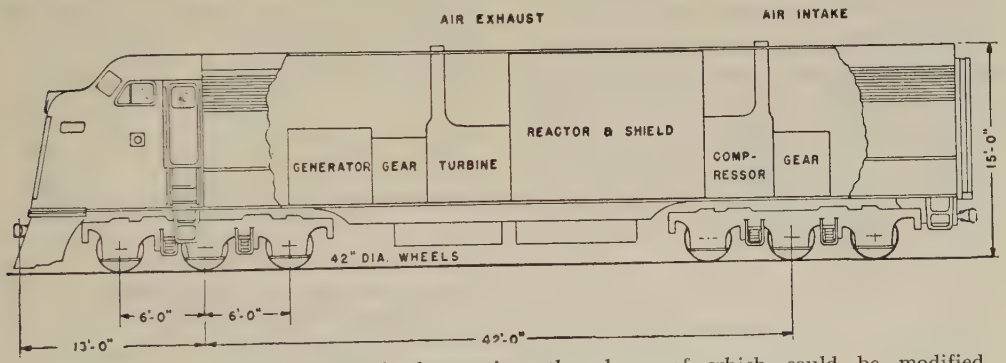
An atomic gas-turbine locomotive.

If the military will build the first one, it will provide itself with a valuable asset and will make an important step toward wider application.

(*Railway Locomotives and Cars*, July, 1955.)

An atomic-powered, gas-turbine-electric locomotive, built by the military service was proposed by Bruce C. Gunnel, chief mechanical engineer, Southern, at a meeting of the Atomic Industrial Forum, held in New York on May 23-24, 1955.

transmitted through overhead lines to conventional electric locomotives. This is a very feasible way to use atomic energy but at the present time, I do not believe the electric locomotive with all its overhead wires, and other parts of its



Section of an all-purpose atomic locomotive, the shape of which could be modified for yard service. Total length of the locomotive is 68 ft.

In outlining the reasons for his proposal, Mr. Gunnel spoke, in part, as lollows :

The American railroads are interested in atomic energy in a general way, because anything that affects industry, also reacts on the transportation business, but our primary interest is in the use of atomic energy to furnish the power to haul our trains, at a lower over-all cost than is being done by our present equipment.

« This may be accomplished by using atomic power in one of two ways, indirect or direct. If the indirect is used, the atomic energy would be converted into electrical power at stationary plants and transmission system, can compete with the Diesel locomotive even if the electric power, produced by atomic energy, could greatly reduce our present electric cost.

« This is the picture as I see it today, but if the cost of present day Diesel fuel continues to increase so a to become prohibitive for railroad use, it is likewise possible to see a different picture with regard to the electric locomotive.

« I mentioned the use of atomic energy in a direct method on a railroad locomotive. This would mean that the atomic fuel would be carried in the locomotive and converted into power on this unit.

« At this point it would be well to

define a locomotive in general terms. A locomotive is an engine which converts fuel or electric power into tractive force at the rails.

« The coal or oil fired reciprocating steam engine has definitely proved itself to be inefficient from a fuel cost, maintenance cost an availability standpoint.

« In my opinion, the steam non-condensing turbine, directly connected, or electric driven locomotive is in the same category as the reciprocating steam locomotive, with an additional disadvantage of being so large that it is only usable in heavy mainline service. If a condensing unit is used, in an effort to save water, the locomotive would be so large that it would be useless on most railroads.

« The internal combustion (Diesel) electric locomotive is the most economic and versatile of all modern locomotives. A Diesel-electric locomotive can be made up of one to six, 1 500 to 2 400-HP single units, weighing about 250 000 lb each, with all weight on drivers. Such a locomotive can be used in yards or on branch and main lines.

« The other type of locomotive which seems to be showing some promise in recent years, is the gas turbine-electric. This type unit is only in its early stages of development and road tests, and so far it does not compare favorably with the Diesel-electric locomotive. It can be made into units of comparable size and weight to the Diesel, which is one of its good points. Impurities in the fuel which damage the blades and low efficiency at less than full load output are two of the main disadvantages.

« A few of the important points a locomotive should have are as follows :

1. Economic fuel consumption.

2. Such size and weight that it can be used as a switching unit in yards, or coupled in several multiple units, with single control operation, for use in branch or main line service to pull heavy trains at fast speeds.

3. Require a minimum of maintenance cost, and out-of-service.

4. Simple to operate with a minimum operating crew.

5. Total original cost and operating cost should be kept to a minimum.

6. Last but not least a top priority requirement is that the locomotive be safe under normal and abnormal operating conditions.

« Our interest at this time is the potential use of atomic power by a railroad locomotive. Atomic fuel has a great deal more heat per pound, than do our present types of fuel, as can be seen by the following table :

Fuel.	*Btu per lb.*
Wood	8 000
Coal	14 000
Oil	20 000
Uranium 235	40 000 000 000

« From this, it can be seen that atomic energy has quite a potential possibility in the power field, assuming its present cost will be reduced as its use increases.

« As has been shown, an atomic energy source will generate heat. This heat can be used to generate steam or to heat gas (air) for use in an engine or turbine.

« Our next step now is to see in which type of locomotive this heat can best be used.

« The conventional steam-reciprocating locomotive has such low efficiency and availability, I think it should be disregarded. The efficiency of this locomotive is usually seven per cent or less.

« The Diesel-electric internal combustion locomotive is the highest in efficiency, about 28 %, the highest in availability of all locomotives at present, but an internal combustion engine does not seem to be adapted to the use of atomic energy.

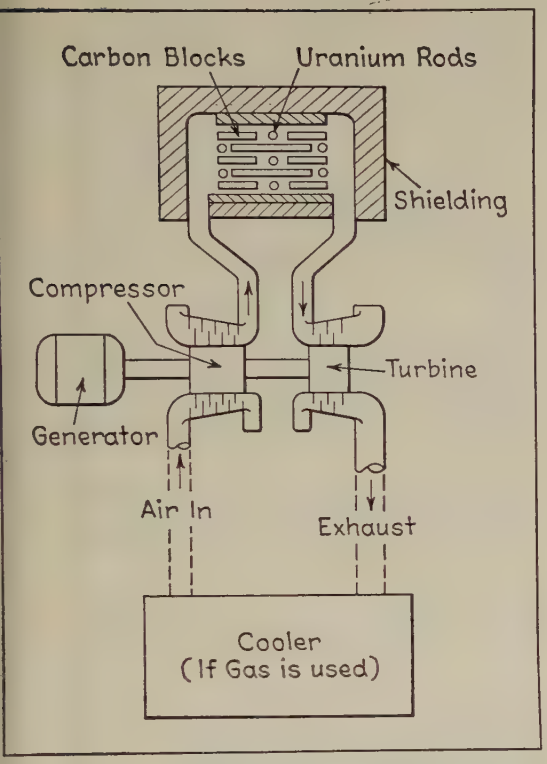


Fig. 1. — Air or gas cooled reactor and gas turbine for power generation.

« The steam turbine-electric has not proven itself to be satisfactory for locomotive use, even though much effort has been exerted to develop this type of power. The efficiency does not seem to be much above the steam reciprocating locomotive and among other disadvantages, it requires a large volume of water. The use of a condenser has never proven satisfactory on a locomotive, so I would recommend against considering this type of locomotive for use of atomic power.

« This leaves us the gas-turbine-electric locomotive to consider. The efficiency of this type locomotive is approximately 18 %, with a turbine blade temperature of 1 300° F, and its availability should be high. The use of atomic energy to heat a gas, say — air, for the turbine seems possible, and I recommend we consider this type locomotive as being the most likely for this use.

« If we take a gas-turbine-electric locomotive adapted to use atomic energy in place of conventional fuel (coal or oil), then the main factor we will have to consider from a general design standpoint is to replace the combustion chamber and fuel storage and handling equipment with an atomic reactor (furnace).

« The reactor may be a solid fuel type or it may be liquid fuel type It also may use a direct air-cooled cycle or an indirect liquid-cooled cycle. One advantage in the direct air-cooled cycle

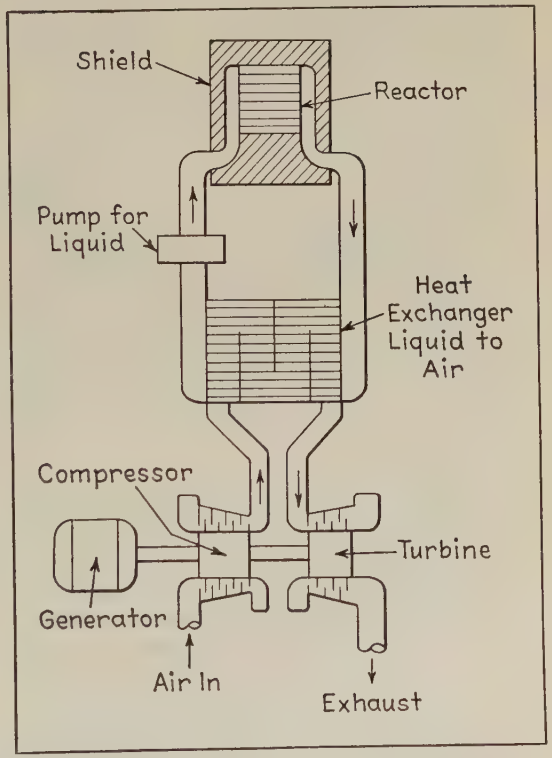


Fig. 2. — Liquid cooled reactor and gas turbine for power generation.

reactor (fig. 1), is its simplicity due to the few small number of working parts.

« If a solid type of fuel is used, there need not be any radioactive fluid present to spill or leak out in the case of an accident. Also the reactor with solid fuel is mechanically controlled, while a liquid type fuel reactor eventually may have inherent self-control incorporated in the design. The indirect liquid-cooled cycle type reactor may be used (fig. 2). In this case, a liquid coolant is passed through the reactor, which absorbs the reaction heat. This hot radioactive liquid is then pumped through a heat exchanger where air or other gas, will take up this heat and carry it to the power turbine. This essentially eliminates potential danger from the use of air direct from reactor to atmosphere.

« The direct air-cooled cycle reactor would take air from the atmosphere, compress it and pass it through this reactor where it would absorb heat up to about 1 300° F, as in the case of the gas turbine locomotives in service on the Union Pacific, and then through the power turbine where this heat would be converted into power, then the air would be discharged into the atmosphere. This exhaust air may be highly contaminated and, if so, would be a potential danger to living bodies which come close to the point of discharge. As the exhaust gases mix wth large quantities of outside air, the dilution will assist in reducing such danger.

« A very careful study would be required to go into all the reactor details but from this it can be seen that each type has about as many advantages or disadvantages as the other.

« Our problem now is to see how such an atomic reactor can be fitted into a locomotive.

« In selecting the size and weight for an atomic locomotive, we should start with one that can be used in freight and passenger road service, and in switching service, on most of our standard American railroads, and also could be used by our military. It should be designed so it can be operated as a single unit or as multiple units from one control cab. The controls should be simple and maintenance cost reduced to a minimum. It should be designed so there is a little potential danger to personnel or property.

« General specifications of such a locomotive could be as follows :

Atomic reactor heat output, HP . .	15 000
Shielding weight estimate, lb . . .	85 000
Gas turbine, into generator, HP . .	3 000
D.C. electric generator, HP . . .	3 000
Six traction motors, HP	500
Two three-axle trucks. Wheel diameter, in.	42
Total weight of locomotive, lb. . .	384 000
Weight on drivers, lb.	384 000
Tractive force continuous, lb. . . .	96 000
Length of locomotive, ft.	68
Height of locomotive, ft.	15
Width of locomotive, ft-in.	10-6
Train steam-heat exchanger, lb. per h	3 000

A Diesel locomotive uses about 2 gal of fuel per 1 500 HP per mile in road service. The overall efficiency of this Diesel will be about 28 %, at full throttle, full load, and this efficiency drops only slightly as the throttle and load is reduced.

« A present day oil-fired gas turbine will have about 15-18 % overall efficiency at full throttle full load. This efficiency falls very rapidly as the throttle and load is reduced due to the characteristics of the turbine design, and also due to the large compressed air requirement of the gas fired turbine in order to control the temperature.

« There is no efficiency data available on an atomic energy gas-turbine, so all I can do is use my own judgment in order to arrive at some figure.

The turbine	20 % efficiency
The electrical transmission .	80 % efficiency
Total efficiency	16 %

TABLE I

Data	Diesel	Atomic
1. Locomotive efficiency (per cent)	28	16
2. Fuel per mile (average)	28 lb (4 gal)	.000,0245 lb
3. Total fuel capacity lb (estimated)	14 000 lb	33 lb (15 kg)
4. Locomotive miles per month (estimated)	12 000	12 000
5. Locomotive miles per year (Item 4 × 12)	144 000	144 000
6. Portion of total Btu's used per fueling, per cent (estimated)	100	20
7. Pounds used per fueling (Item 3 × Item 6)	14 000	6.6
8. Total Btu's per lb of fuel (based on data available)	20 000	40 000 000 000
9. Total Btu per mile used (Item 2 × Item 8)	560 000	982 000
10. Work in Btu per mile (Item 1 × Item 9)	157 000	157 000
11. Total Btu per fueling (Item 7 × Item 8)	28 000 000	264 000 000 000
12. Years between fuel changes (Item 11 ÷ (Item 9 × Item 5)	.00347 (once a day)	1.87
13. Fuel cost new (based on Prof. Lyle Borst's paper at Atomic Industrial Forum Meeting, March 1954)	$.0142857 lb	$9 090.90 lb
14. Credit for poisoned fuel (estimated 1/5 of cost of new fuel)	—	$1 818.18 lb
15. Net cost fuel per lb.	$.0142857 lb	$7 272.72 lb
16. Net cost fuel per fueling (Item 3 × Item 15)	—	$240 000
17. Net cost fuel per year (Item 16 ÷ Item 12)	$57 000	$128 000
18. Net cost fuel per mile (Item 17 ÷ Item 5)	$.40	$ .89
19. Per cent fuel cost (from Item 18)	100	222
20. Fuel lb per HP per hr (Item 2 × 40 mph ÷ 3 000 HP)	.38	.000 000 326
21. Fuel lb per HP per hr atomic plane (Life February 7, 1955) (800 mph × 5 lb) ÷ (14 000 miles × 475 000 HP × .18 per cent efficiency)	—	.000 000 340

« I feel that all these efficiencies are realistic.

« From these figures, we can list the following data in an effort to compare an atomic powered gas turbine-electric locomotive with a modern Diesel electric locomotive. (See Table I.)

« We should now weigh the good and bad points of each of these two types of locomotives, and where possible, relate these comparisons in terms of money — namely, dollars.

« Fuel is our first item to consider. The purchase price of fuel on a large fully dielselized railroad operating about 1 000 Diesel units of 1 500 HP each will run about 160 000 000 gal at 10 cents per gal, or $ 16 000 000 per year.

« It would take 500 atomic units of 3 000 HP each, to « atomize » this railroad.

« The development cost of the first atomic locomotive would probably be at least $ 20 000 000. The cost per 3 000-HP unit, after mass production manufacturing is started would probably be about $ 1 000 000 each for the first 500 locomotives. If the development cost is absorbed by the first 500 units, then they would cost $ 1 040 000 each, as against a two-Diesel unit costing about $ 300 000. The expected life would be about 15 years for each type. Therefore, an atomic unit would cost $ 1 040 000 + 15, or $ 69 333 per year, and two Diesel units would cost $ 300 000 + 15, or $ 20 000 per year.

« The maintenance cost for a 3 000 HP

Diesel locomotive is about $ .40 per mile, or 144 000 × $ .40 = $ 57 600 per year. In light of the fact that many parts of an atomic locomotive will be radioactive (hot), causing it to be unsafe for mechanics to make repairs on the locomotive, the assemblies will have to be removed and set aside to cool off which may take months or years before repairs can be made. In some cases, the parts may have to be « dumped », which would result in a complete loss. A conservative estimated figure for maintenance cost per mile will be twice that of a Diesel, or $ .80 per mile, or $ 115 200 per year per 3 000-HP unit.

« The fuel estimate is taken from Table I. The storage and handling of used atomic fuel is very difficult and requires specialized equipment and personnel, but the quantity of the fuel and the frequency of refueling will be much less than for Diesel fuel. The cost of fuel handling should balance each other. However, I am combining this possible additional cost with that of the liability insurance and other costs.

« The cost of the train crews should be the same for both types of power.

« These are some of the main costs and are enough for our present needs as shown in Table II.

« We now come to the subject to which no one living knows the answer, so I feel that I can speak freely. Safety-liability.

« This can be broken down into two phases. One is the normal danger that personnel are subjected to the radioactivity of the atomic fuel. I believe this phase can be handled satisfactorily with the present know-how and the careful training of railroad men. This, of course, will cost a great deal more than it does to train and supervise Diesel maintainers, say, $ 10 000 00 per year per atomic locomotive.

« The other phase is what will be the consequence when something goes wrong with the equipment as a result of the failure of mechanical parts or personnel failure. I want to make it clear that I do not believe there is much danger from a controlled chain reaction, resulting in an atomic explosion; in fact, I am going to disregard this possibility. What I am talking about is a result of the failure of some safety equipment which would stop the control rods from operating. The reactor in this case could get so hot that it might melt down and run

TABLE II

Data	Diesel	Atomic
1. Expected life, years	15	15
2. First cost *a* 15-yr life	$ 20 000	$ 69 333
3. Maintenance per year (Diesel 40 c. per mile)	$ 57 600	$115 200
4. Cost fuel per year (Item 17, Table I)	$ 57 600	$128 000
5. Cost fuel storage, handling and liability in addition to Diesel (estimated)	—	$ 25 000
6. Train crews same as Diesel	—	—
7. Extra cost supervision and training over Diesel (estimated)	—	$ 10 000
8. Total cost per year per locomotive	$135 200	$347 233
9. Operating cost per mile	$ .54	$ 2.40
10. Per cent operating cost (per cent)	100	258

Note : Interest on above fixed charges not considered.

out on the ground. Of course, if this happened, the ground would become so radioactive that personnel could not come near it. The track would have to be abandoned for a long period of time, or the ground dug up and carried away by the use of very special equipment. »

Mr Gunnel then proceeded to paint a vivid word picture of a collision between two atomic locomotives on the « Uranium Valley Railroad » caused by a highway truck in a densely populated area during a time when all airplanes were grounded by bad weather. In his story, which he says is pure fiction, but a possibility, the reactors get so hot that they melt and run into the street. The result is that an area of several hundred feet radius has to be closed off to be cleaned up later by means of a very expensive process.

He concludes by saying, « I do not believe that an atomic powered locomotive can be justified for use on our American railroad system for serving the public at the present time, or any time in the next 10 years, but there is one place I feel that an atomic locomotive would prove very valuable at the present time and that is in military service. A 3 000-HP unit may be a little large, but this can probably be reduced without too much difficulty. Think what a wonderful advantage it would be to have a military locomotive operating in some remote field, that only required refueling every six months.

« I recommend the military service as the first and most likely place for such a unit to be used, and it certainly does have great possibilities in this field. »

[625 .156 & 625 .216]

Development in high capacity shock absorbers and buffers,

by A. P. Fitzjohn, (*)

Member, The Institution of Mechanical Engineers.

(*The Chartered Mechanical Engineer*, September 1955).

The object of this paper is to show modern trends in the design, and applications of pneumatic and hydraulic buffers having capacities for shock absorption far in excess of conventional spring buffers.

The word « buffer » should be regarded as a general term meaning a device for the absorption of the kinetic energy of a moving object whose state of motion is changed owing to impact.

Design requirements in buffers. — A buffer, to operate efficiently, should absorb the kinetic energy, dissipated due to a change in the motion of a moving mass, whilst applying as small a reaction load as possible (preferably shockless) to the vehicles, or vehicles and stop concerned.

Development and research. — Hitherto, it can hardly be said that there has been much constructive scientific research into the functions and energy absorption of buffers under actual operating conditions. Generally, a wagon has been fitted with a type of buffer and released into service to await results, if any, after a lengthy period.

Shunting tests along a line or in a siding present many difficulties. The collection and recording of reliable data become a complex matter, whilst the problem of achieving and repeating any desired speed of impact is almost insuperable.

Basically, it is required to know the quantity of energy a given buffer will absorb before « going home solid » and also the magnitude of the accompanying reaction load. Any excess of kinetic energy over the capacity of the buffer will appear as an indeterminate shock load on the wagon structure.

To overcome these difficulties and thus obtain accurate information, the author installed a testing ramp and electronic recording gear shown in figure 1. On this ramp a bogie, which can be loaded to simulate moving bodies including railway wagons, can be released to achieve known speeds of 3-25 m.p.h. at the point of impact. The stroke indicator consists of a series of contacts alongside a copper strip. Shorting contacts, suitably mounted on an arm fixed to the bogie, close a circuit

(*) Mr. A. P. Fitzjohn served an apprenticeship with Richardsons, Westgarth & Co. Ltd., Marine Engineers, Middlesbourgh, from 1899 to 1904. Following a few years on Civil Engineering Contracts he joined the original Birtley Iron Company in 1912 as Manager.

In 1919 he invented the continuous all rolled process for the production of forged steel railway buffers and became associated with George Turton, Platts & Co. Ltd., Sheffield, first as Works Manager and, since 1926, in the additional capacity as a Director of the Company.

Incidental with the development of the forging processes the design of buffers have been improved for locomotives and rolling stock throughout the Commonwealth and in some foreign countries. Since 1945 he turned his attention successfully to buffers outside the scope of those of a conventional character in order to meet the growing demand for energy absorption of a very high order when arresting heavy and high speed masses in steelworks, ships when berthing on dock or harbour fenders, and other heavy duty applications.

between the contacts and the strip as the bogie passes them. Each contact thus marks on a diagram, indicating that the bogie has reached that point. The first contact is reached 12 inches before the buffer heads meet, the second actually on impact, and over the rest of the stroke a choice can be made of every half inch up to 24 inches stroke.

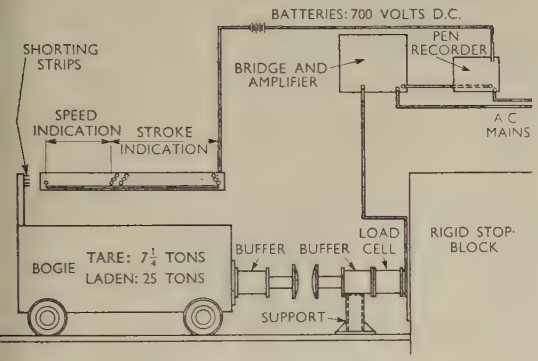


Fig. 1. — Arrangement of test equipment.

During each run, the electronic equipment records on a time base the following information :

1) the reaction load to the buffer under test at all points along the buffing and recoil strokes;

2) the time for the bogie to travel a distance of 1 foot prior to the start of the buffing stroke;

3) the time for the bogie to travel certain preset distances along the buffing and recoil strokes.

From this information further details may be derived namely :

1) initial speed of the bogie and hence the input kinetic energy;

2) energy absorption of the buffer;

3) energy given back on recoil;

4) the load that is imposed on the vehicle or buffer support structure, and

5) velocities and deceleration at all points along the strokes.

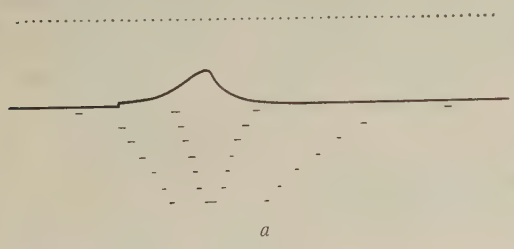
Figure 2 shows :

1) the form of recording obtained from the equipment for a pneumatic buffer of 18 inches stroke under test;

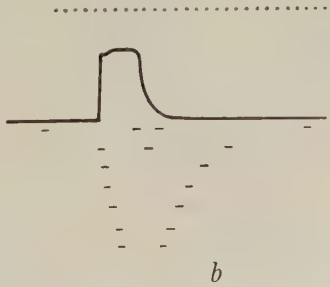
2) the form of recording obtained for a hydropneumatic buffer of 4 ½-inch stroke under test.

Developed from such recordings for pneumatic buffers figure 3 is self-explanatory, but attention is drawn to the velocity and deceleration features, and in particular to the reactive loads imposed on buffer mountings. In one case the maximum load is a known quantity, and in the other an indeterminate quantity.

Pneumatic buffers. — There has been a long-felt need for buffers of greater energy-absorbing capacity than those in use on rolling stock, both at home and

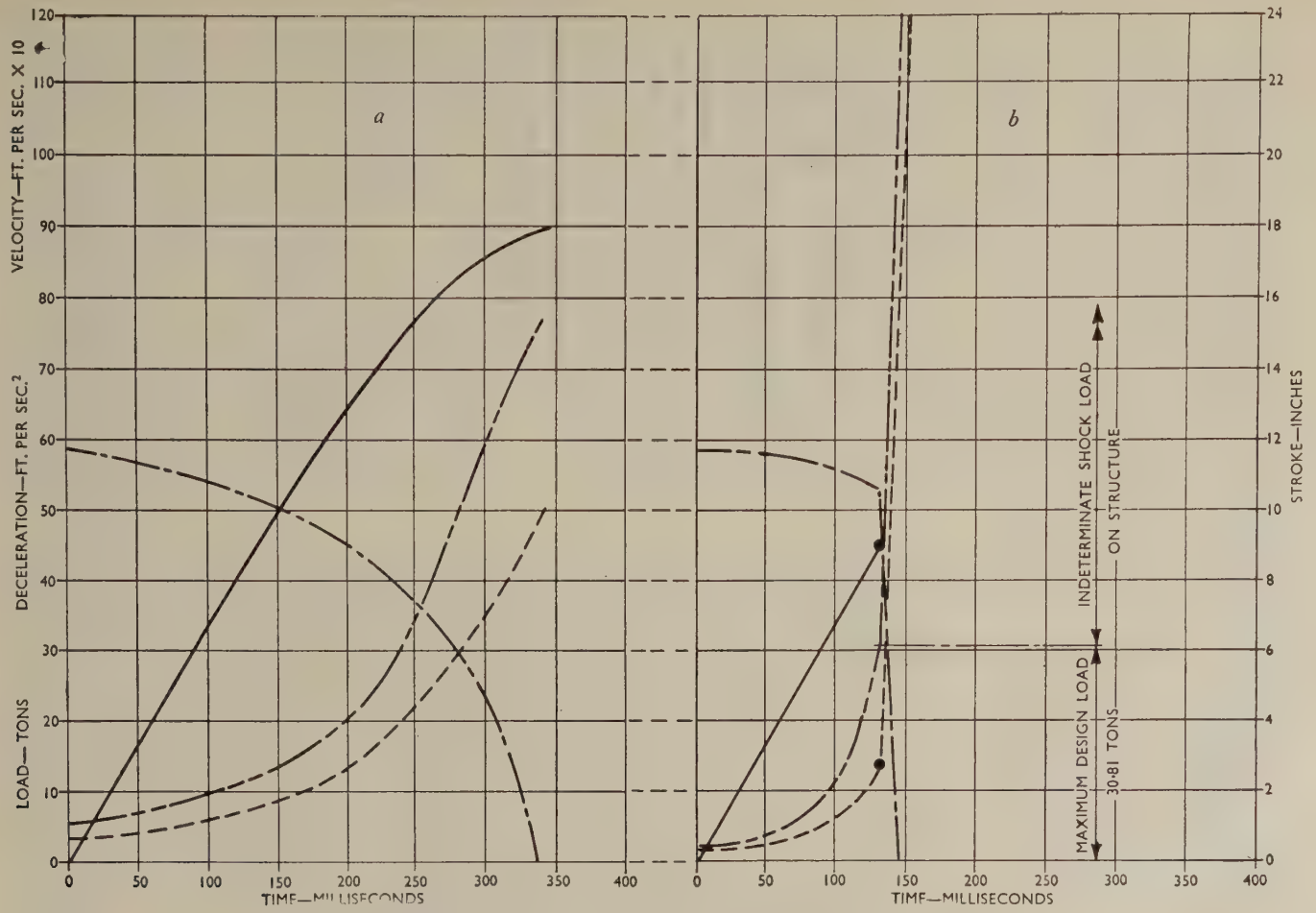


a) Pneumatic buffer of 18 inch stroke.



b) Hydropneumatic buffer of 4 1/2 inch stroke.

Fig. 2. — Facsimile test recordings.

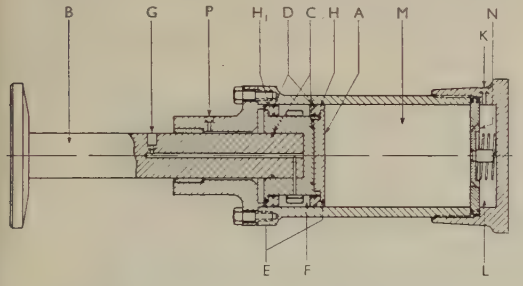


a 330-in.-ton, 18-inch stroke of sufficient energy absorbing capacity.
b 60-in.-ton, 9-inch stroke of energy absorbing capacity, arresting a moving mass.
The destructive force applied to the structure in this example should be noted.
Curves derived from electronic test recordings.

——— Stroke. —·—·— Load. — — — — Deceleration. —·—·— Velocity.

Fig. 3. — Comparison of characteristics of two buffers showing correct and incorrect application.

overseas for a wide variety of applications, and the author, realizing the limitations of spring buffers, directed attention to the use of air. As energy is absorbed in compressing air the idea was conceived that if the expansion of the air could be controlled after compression, then the recoil energy would be considerably lower than the input energy. Preliminary trials proved effective, but the problem remained of retaining a determined weight of air at varying high pressures for lengthy periods, even running into several years.



A Piston.
B Buffer rod.
C Static seals.
D Toroidal piston seals.
E Collars.
F Oil chamber.
G Oil fill-up valve.
H, H_1 Resinoid plastic rings.
K Air fill-up valve.
L Recoil chambers.
M Cylinder.
N Recoil control valve.
P Grease nipple.

Fig. 4. — Sectional arrangement of pneumatic buffer.

Experiments were made with many types of piston seals but it was not until the sealing arrangement shown in figure 4 was devised, that success was achieved. The seal retaining the air is located in a floating piston housing, on the opposite side of which is an annular chamber filled with oil. The air pressure in the buffer cylinder is transmitted by the housing to the oil, thus the pressure on the seal itself, owing to compression or expansion, is always balanced, and maintains a positive air tight joint between the bore of the cylinder and the piston.

The outstanding characteristics of pneumatic buffers are :

1) the initial and final loads are easily adjusted whilst in service to suit operating conditions, by merely varying the initial pressure;

2) energy given out on recoil is only a fraction of the input energy;

3) much higher energy absorption capacity than is possible with steel or rubber springs of equal length;

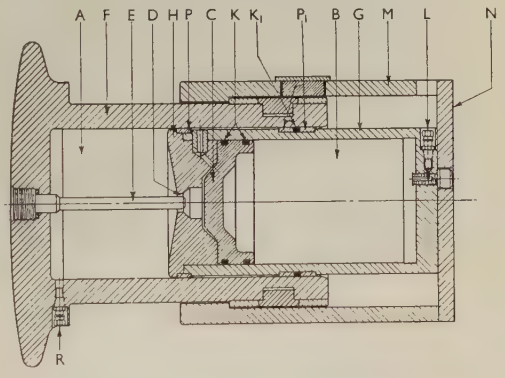
4) comparatively light weight and economical design for long strokes and high capacities;

5) extreme flexibility;

6) simplicity of maintenance.

The maximum energy per inch of stroke a pneumatic buffer can absorb is 22 inch tons. This, however is not always sufficient for ships berthing alongside quays or jetties, heavy rail vehicles in steel works such as ingot chariots, hot-metal carriages and the like, and railway terminal stops.

Hydropneumatic buffers. — Investigations proceeded along the lines of hydraulics, and buffers developed to make use of the flow liquid through an orifice for energy absorption and air under pressure for the return of the buffer to the free or extended position. The science of hydraulics is not one of exact mathematics, and as so often happens, there is a difference between



A Oil chamber.
B Air chamber.
C Floating piston.
D Orifice.
E Control stem.
F Plunger.
G Buffing cylinder.
H Orifice head.
K, F_1 Toroidal seals.
L Schrader valve.
M Buffer casing.
N Baseplate.
P, P_1 Resinoid plastic rings.
R Oil fill-up valve.

Fig. 5. — Sectional arrangement of hydropneumatic buffer.

theory and practice; in this connexion the testing equipment shown in figure 5, played a vital part in the establishment of expirical formulae enabling the control stem and orifice to be accurately designed for any particular duty. Figure 5 shows a sectional view of a hydropneumatic buffer of 4 ½ inches stroke which is nominally a constant-stroke buffer regardless of impact velocity. It is, however, obvious that during the stroke the air load in the air or buffing cylinder is increasing, and to obtain full stroke the applied load must exceed the final air load. A hydropneumatic buffer designed for a given speed will accommodate any load and energy below its designed maximum capacity, but if struck at a higher speed than that for which it is designed it is still capable of absorbing the energy. The load, however, will increase proportionately with the square of the speed, so allowance should be made for adequate factors of safety, since only the physical strength of the buffer and mounting will decide the upper limit of the range of use.

The maximum energy absorption capacity of hydropneumatic buffers is of the order of 150 inch tons per inch of stroke, and the flexibility is shown in the recorded results of tests as follows :

Vehicle, loaded wagon of 25 tons gross running into solid stop, buffers of 4 ½ inches stroke fitted to both, combined total stroke 9 inches; at

3.78	m.p.h.	energy	71.5	inch tons,	load	14 tons,	stroke 7.6 ins.
9.07	m.p.h.	energy	412	inch tons,	load	67 tons,	stroke 8.55 ins.
13.3	m.p.h.	energy	888	inch tons,	load	143 tons,	stroke 8.75 ins.

In the design and development of these new buffers the main object is to absorb the maximum designed energy in the effective stroke of the buffer, and to determine the final load on the buffer mountings for any particular duty. If a buffer of insufficient capacity is employed, only a fraction of the total energy will be absorbed before the buffer is driven home solid, with a negligible reduction in the speed of the vehicle. The vehicle or moving body will, therefore, be brought to a sudden standstill, and an indeterminate shock loading imposed on the vehicle frame and engaging stop. Shocks of this nature are the direct cause of much damage to vehicles, goods in transit, injuries to railway passengers, and harm to E. O. T. cranes and other moving machines. These conditions are usually accepted as inevitable risks that must be taken in our fast-moving age, but engineers should recognize that adequate shock absorption would eliminate, or at least greatly minimize, the effect of collisions and the consequent repairs and maintenance.

Shock absorbing units employing the principles mentioned are applicable to a variety of purposes, including vehicle suspension and angular floating mountings.

[621 .431 .72 (73)]

Diesel-hydraulic railcars in the U.S.A.

« RDC » cars in use on 14 United States and two Canadian railways are operating 31 805 miles daily over 5 812 route miles.

(*The Railway Gazette*, September 16, 1955.)

A Diesel development with an increasing vogue in the United States is the Diesel-hydraulic-railcar. The original Budd-built car was a demonstration model which appeared in 1949, and since has operated over 50 different railways in the U. S. A. and Canada, performing a total of over 200 000 miles. A year later the first of these cars was in regular service, and there are now over 150 at work, on 14 United States railways, two in Canada, and also in Australia, Saudi Arabi, and Cuba.

The cars are known as « RDC » units (« rail Diesel car ») and are of four types, three carrying passengers and the fourth for baggage or mail only, or both. The passenger cars all measure 85 ft. overall; the « RDC-1 » seats 89 passengers; the « RDC-2 » 70 passengers with a 17 ft. baggage section; and the « RDC-3 » 48 passengers with a similar baggage section and a 15 ft. section for Post Office use. The « RDC-4 », of which very few examples have been built, is 73 ft. 10 in. long only, the reduction in length being

Two « RDC » Diesel-hydraulic railcars with multiple-unit control on the Los Angeles-San Diego service, Atchison, Topeka and Santa Fe Railway.

to allow loading to full capacity without overloading the engine. When fully loaded, the last-mentioned weighs 63 ½ tons; the « RDC-1 » weighs 56 ¼ tons with all seats occupied, and the « RDC-2 » and « RDC-3 » between this figure and 63 tons according to the amount of baggage carried.

Each car is fitted with two 275-HP six-cylinder Diesel engines, located beneath the floor of the car at the two outer ends; each engine drives the inner axle of the bogie at its own end of the car through the medium of a torque converter. With a power ratio of 8.68 HP per ton, an « RDC » car has an initial acceleration of 1.4 m.p.h. per sec., and can cover 5 miles from a standing start in 5 min.; the maximum speed is 85 m.p.h. Disc braking makes it possible to stop one of the cars from this speed in a distance of 1 900 ft.

Radiators, cooling fans, engine air intake, and other equipment are located in a dome above the roof at the centre of the car, extending to a maximum height of 14 ft. 7 in. above rail; with the under-floor engines, this means that the entire length of each car is available for passenger, baggage, and mail accommodation. The under-floor engines also contribute to an exceptionally low centre of gravity, no more than 4 ft. 4 ½ in. above rail, which safely permits higher than normal speeds round curves.

Variety of duties.

The « RDC » cars are being used for a great variety of duties, ranging from suburban services, with from two to four or more cars coupled and worked multiple-unit, to the 924-mile runs of the Western Pacific *Zephyrette* cars between Salt Lake City, Utah, and Oakland Pier, California. In general, the single cars are manned by a driver and a conductor only, but in accordance with American crew rules, larger crews are carried with the multiple-unit assemblies, including a fireman in most cases, a baggageman if much baggage is handled, and an additional conductor to handle tickets on suburban runs.

At present the New York, New Haven & Hartford Railroad, with 40 « RDC » cars in service making 9 241 car-miles weekly (4 794 train-miles over 919 route-miles of line), is the biggest user. This company has now decided to turn over practically the whole of its shorter-distance workings to cars of this type, of which it has a further 55 on order. The New York Central has 20 cars, the Pennsylvania-Reading-Seashore Lines 12, the Baltimore & Ohio 10, and other railways smaller numbers; there are 7 on the Canadian Pacific and 3 on the Canadian National Railways; overseas 16 are in use on the Consolidated Railways of Cuba, 3 on the Commonwealth Railways of Australia, and 3 on the Saudi Government Railway in Arabia. By the end of 1955 a total of 122 « RDC » cars in the U. S. A. was operating over 5 812 route-miles a total of 17 344 train-miles and 31 805 car-miles daily.

The reliability record of these cars has been extremely good, and nearly all the users report an availability of over 90 %, in some cases up to practically 100 %. On the Western Pacific Railroad the two *Zephyrettes*, which each average 792 miles daily on their 924-mile runs, have never failed to start a scheduled run since they were introduced in September, 1950, replacing three steam train sets consisting of locomotive, baggage car, and three coaches, with which there was considerable annual loss of revenue. On one run a car failed to complete its journey by 11 miles; on another one of the cars was hauled 620 miles by a Diesel locomotive after a breakdown; and these have been the only two failures in service in 1 200 000 miles of running. Low running cost also are a feature of « RDC » operation; a well-known independent firm of accountants has assessed the average running expense of these cars on all types

of service in the U. S. A. as slightly under 80 cents a mile.

In order to popularise the cars, the various railways using them have given them names, such as the Western Pacific *Zephyrettes* already mentioned. On the New York Central they are *Beeliners,* on the New York, New Haven & Hartford *Schoreliners,* on the Boston & Maine *Highliners,* on the Baltimore & Ohio *Speedliners,* on the Canadian Pacific *Dayliners,* and on the Canadian National *Railiners.* On some railways, such as the New York, New Haven & Hartford, branches on which passenger service had been abandoned have been provided once again with passenger trains by this means, with a good response from the public. On other routes, both main and branch, more frequent service than before is being given with the railcars, with acceleration in addition, due to the rapid acceleration from stops that they make possible.

Between Baltimore and Washington, for example, the B. & O. *Speedliners* cover the 38.3 miles in 40 min. with two intermediate stops, 45 min. with four stops, and 50 min. with six stops, and many of their short point-to-point runs on this and other railways are timed at over 60 m.p.h. from start to stop. In Australia, where the « RDC » cars are normally used by the Commonwealth Railways for service between Port Pirie, Port Augusta, Pimba (for the Woomera rocket range), and Tarcoola, they are also in demand for the conveyance over the length of the Transcontinental line, and one of them holds the record for having completed the journey of 1 051 miles between Port Augusta and Kalgoorlie in 18 hr., at an average speed of 58.4 m.p.h., attaining a maximum speed of 89 m.p.h. This compares with 23 hr. allowed the regular Diesel-hauled « Trans-Australian » express, and the 44 hr. of the previous steam-hauled service.

Long distance « RDC » trial.

Hitherto the only regular long-distance running of « RDC » cars in the United States has been that of the Western Pacific *Zephyrettes* already referred to, over the 924 miles between Salt Lake City and Oakland Pier, San Francisco, and these are workings of the « all stations » type rather than express passenger. But a recent experimental return run of a trio of these cars between Washington and Chicago has opened the eyes of American operating authorities to the possibility of using cars of this type for fast limited-stop main line services, which would both help to cut present passenger service losses because of their very low fuel and crew costs, and might at the same time make it possible to offer reduced fares. The Baltimore & Ohio Railroad, over whose metals this test was made, already had had under the consideration a service of this type over the 334.6 miles between Baltimore and Pittsburgh, but the Chicago-Washington trial has opened up a vista of far wider possibilities.

Actually the run was of a special train chartered by the Washington Chapter of the National Railway Historical Society, which was offered a schedule considerably faster than that of any existing Diesel-hauled express train over this route. When the decision had been reached to regard the working as a special trial, the drivers were given liberty to gain time, with the result that the actual running time on the westbound journey, including slowing down to and restarting from eleven intermediate stops and several out-of-course checks, was cut to 12 hr. 7 min., 2 hr. 51 min. less than the scheduled running time, stops omitted, of the « Capitol Limited », the fastest existing train over this route. The total elapsed time, including the duration of all stops, was 12 hr. 29 ½ min., as compared with the « Capitol Limited's » 15 ½ hr. — a gain of precisely 3 hr., and at an overall average speed of 61.5 m.p.h.

Three 550 HP « RDC » cars, Nos. 6515, 6516 and 6550, with multiple-unit control, composed the train, which carried 210 passengers. The extremely rapid acceleration

of these cars was obvious from every stop; from Silver Spring, Washington, the train passed Rockville, 9.1 miles, in 8 min. 45 sec.; from Willard, Attica, 8.1 miles, was passed in 8 min.; from Garrett the passing time to Albion, 15.4 miles, was 13 min. 50 sec. From Washington (Silver Spring) to Cumberland there is considerable curvature, which restricted speed; this 139.1 miles occupied 139 min. 50 sec.

The next section, through the Alleghenies, has a summit level of 2 258 ft. at Sand Patch, approached by heavy gradients with severe reverse curvature; in the 20.2 miles from « Q » Tower at Hyndson to Sand Patch the line rises 1 323 ft, at a continuous average of 1 in 80, up which the average speed was 45.9 m.p.h.; the 150.3 miles from Cumberland to Pittsburgh were run in 169 min. (40 min. less than the « Capitol Limited » schedule). From Pittsburgh to New Castle Junction the 46.6 miles occupied 48 min. 40 sec., and the 146.7 miles from there to Willard were run in 133 min. 40 sec., in both cases inclusive of a brief signal stop intermediately.

Eighty-one m.p.h. start-to-stop.

It was on the two final stretches of fairly straight and level track, however, that the 1 650 HP of three cars was more fully extended, the 128.0 miles from Willard to Garrett being covered in 100 min. (76.8 m.p.h. start to stop), and the 130.7 miles from Garrett to Rock Island Junction, outside Chicago, in the very fast time of 96 min. 40 sec., at a start-to-stop average of 81.1 m.p.h. These cars are designed for a cruising speed of 70 m.p.h. and, as already mentioned, a maximum of 85 m.p.h., but over the latter stretch speed averaged just over 85 m.p.h. for 115 ½ miles continuously, with a maximum of 88, without any engine trouble; by general agreement of the passengers also, the riding of the cars at the highest speeds was excellent. Including three service stops between Rock Island Junction and Chicago, the final 150.4 miles from Garrett occupied 129 min. 45 sec., 50 ¼ min. less than the « Capitol Limited » schedule.

The return journey had similar characteristics, including in particular a start-to-stop time of 97 min. 40 sec. over the 130.7 miles from Rock Island Junction to Garrett (80.6 m.p.h.), followed by one of 96 min. 50 sec. over the 128.0 miles from Garrett to Willard (79.3 m.p.h.); for 258.7 miles continuously, therefore, an 80 m.p.h. average was maintained. A slightly different route was followed through Pittsburgh than on the outward journey; the actual running time over the 774.7 miles from Chicago to Washington was 12 hr. 23 ½ min., but the overall time was 13 ¾ hr., as there was a layover of 63 min. at Cumberland while a meal was being taken. The « Capitol Limited » is allowed 15 hr. 5 min. running time and 15 hr. 25 min. inclusive of stops.

Hitherto it has been impossible to make the journey between Washington and Chicago, by either the Baltimore & Ohio or the Pennsylvania route, without night travel, but this trial has proved that with « RDC » cars an overall time of between 13 and 14 hr. would be practicable, so that the journey could be scheduled comfortably between, say, 8 a.m. and 8 to 9 p.m. westbound, and between 7 a.m. and 9 to 10 p.m. eastbound (allowing for the 1 hr. difference between Eastern and Central Time). The Baltimore-Washington-Pittsburgh proposal of the B. & O., already mentioned, was to use an 89-seat « RDC-1 » car coupled to an « RDC-2 » or « RDC-3 » with baggage space and the passenger accommodation converted to a kitchen and dinette-lounge, to replace the existing semi-fast « Washingtonian. »

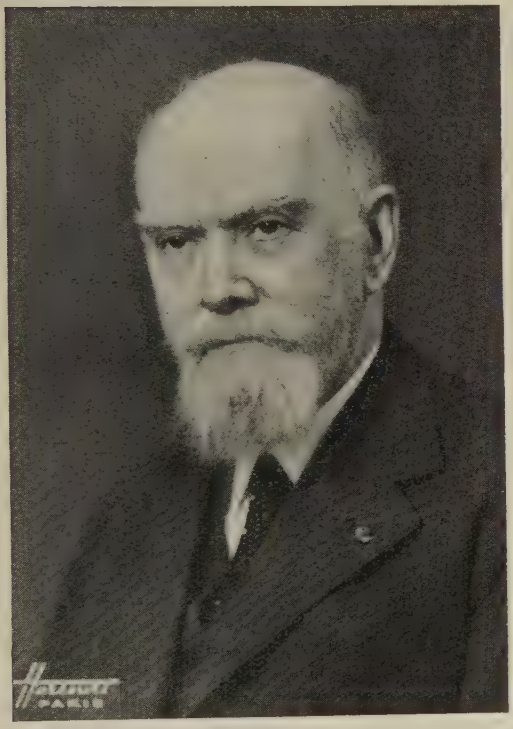
[385. (09 .2]

OBITUARY.

Charles GUFFLET,

Former Manager of the French Midi Railways.

Former Member of the Permanent Commission of the International Railway Congress Association.



We have recently learnt of the death on the 8th August 1954 of M. Charles GUFFLET, former Manager of the French Midi Railways and former member of the Permanent Commission of our Association.

We give below, from the *Revue Générale des Chemins de fer*, particulars of the career of this distinguished engineer and eminent French railwayman.

M. Charles GUFFLET was born in 1870, and at an early age entered the « Ecole Polytechnique », which he left to join the « Ponts et Chaussées » Department. His first appointments were at St. Jean-de-Maurienne and Libourne. He was noted for the strong preference which he always showed for the mountain country and for his native soil of the Bordelais, whence he inherited his vivacity and shrewdness combined with the sound principles which governed his judgement.

Members of his family had preceded him in the Midi Railway system. He himself entered the service in 1898 in the Operating Department, of which he became Manager in 1913, after being appointed Assistant Manager at Bordeaux and later on in Paris. He was appointed Deputy Manager in 1926.

It was during these years, due to the energetic stimulus of his Manager, M. Paul, that the Midi Railway Company took certain bold steps in order to develop economically the areas served by the line. This was effected by the electrification of the system — one of the first to be electrified in Europe — by taking advantage of the abundant water supply from the Pyrenees, providing conditions favouring the development of new industries and putting a region little known and insufficiently provided with hotel accom-

modation as far as tourist traffic was concerned. M. Gufflet who was in close touch with his Manager became intimately concerned in this vast development, which he pursued with the same faith and energy when he succeeded M. Paul in 1931.

Other tasks awaited his cooperation. In advance of the concentration, which the S. N. C. F. were to put into effect later on, the Companies decided to group some of their services under a common control. M. Gufflet was called upon to preside in particular over the Central Office for Waggons and the Common control. Everything helped to smooth over these amalgamations and to get them agreed to : his organising ability, his authority, and also a circumstance which lay in the particular quality of his nature, namely his entire selflessness, a type of modesty which did not exclude a strong will and the desire to seek out objectively those solutions which would most appeal to the general interest.

These qualities moreover became outstanding in the service of the systems as a whole when the Management Committee was instructed to negociate with the State in 1933 the codicil which introduced far-reaching modifications to the 1921 Convention and to the structure of certain railways. None of those who were present at these discussions will have forgotten the smooth and practised firmness with which he led the arguments to an agreed basis.

As from 1934, the results obtained by the Orleans and Midi Railways were pooled. Everybody is aware of the extent of the preliminary difficulties arising with such amalgamations, both on account of traditional claims or legitimate interests which presented the negotiators with some awkward problems, for personal rather than technical reasons. M. Gufflet was the skilled man who could discover an acceptable solution. He made things easy by the loyalty of his arguments, his large-minded appreciation and complete disinterestedness, and the anxiety he showed to give to the new organisations the benefits they were entitled to expect.

At the end of 1936, he retired and his last years were devoted to charitable works in the town of Versailles where he had long lived and where he was a well known personality.

M. Gufflet was loved and respected by his subordinates. He was openhearted and always sought to do the right thing with all men. Although having a reserved nature, it was not easy to get to know him, he was highly cultured both from the literary and scientific sides, and on the rare occasions when he made a speech showed a remarkable gift for impromptu speaking.

M. Charles Gufflet was elected a Member of the Permanent Commission of our Association on the 28th July 1933. His participation in the work of the Association goes back to 1922 when he represented the Midi Railway at the Rome Congress. He was also a member of the delegation of this railways to the London Congress in 1925 and the Paris Congress in 1937, and played an important part in the discussions on many questions of great importance. He always showed the greatest interest in the work of our Association in spite of his very busy life.

We offer his family our very sincere condolences.

The Executive Committee.

[385. (06 .111]

OFFICIAL INFORMATION

ISSUED BY THE

PERMANENT COMMISSION

OF THE

International Railway Congress Association.

Meeting of the Permanent Commission, held on the 22nd October, 1955.

The Permanent Commission of the International Railway Congress Association met on the 22nd October 1955, at 3 p.m., in the Belgian National Railways Headquarters Offices, in Brussels.

* * *

Mr. De Vos, *President*, opening the meeting, addressed a warm welcome to the personalities present. He then requested the Assembly to approve the Minutes of the last Meeting held on the 13th November 1954.

* * *

Mr. Ghilain, *General Secretary*, informed the Meeting of the changes, which occurred in the Permanent Commission since its last session, and of the steps taken to fill the vacant seats.

The Meeting then elected as Members of the Permanent Commission the following personalities :

Mr. E. Clarembaux, Manager of the Permanent Way Department of the Belgian National Railways, to replace Mr. J. Boucqué, retired.

Mr. P.E.N. Skov, General Manager of the Danish State Railways, will replace Mr. E. D. Terkelsen, who has retired;

Mr. W. White, President of the Delaware and Hudson Company, to replace Mr. J. H. Nuelle, now Chairman of the Board of the same Company;

Mr. G. Pande, Chairman of the Railway Board, Ministry of Railways, Government of India, will replace Mr. F. Ch. Badhwar, who has left the railway service;

Mr. Alberto Attisani, Head of the Rolling Stock and Traction Department of the Italian State Railways, to replace Mr. G. Lasz, who has retired;

Mr. Arcangelo Florena, Head of the Staff and General Affairs Department of the Italian State Railways, will replace Mr. F. Fazio, retired.

The personalities who will take over the two vacant seats belonging to Great Britain, following the appointment of Sir Brian Robertson as Member ex-

officio, and the nomination of Lord HURCOMB as Member of Honour, will be designated at a later date owing to the actual reorganisation of the British Railways.

— The complete List of the Members of the Permanent Commission is given on the Appendix, on page 92.

* * *

At the request of the PRESIDENT, Mr. F. Q. DEN HOLLANDER, President of the Netherlands Railways, gave information about the arrangements already made by the Local Netherlandish Organizing Commission for the organisation of the Enlarged Meeting of the Permanent Commission, which will be held at The Hague (Scheveningen) from the 4th to the 8th June 1956.

He supplied full details concerning the programme of the session and of the various ceremonies organized on that occasion.

The PRESIDENT, on behalf of the meeting, thanked Mr. DEN HOLLANDER for the importance of the measures taken up to the present.

Mr. GHILAIN, *General Secretary*, introduced the personalities chosen as Presidents of Section, to preside over the technical discussions, at The Hague Meeting.

SECTIONS I and III. — **Permanent Way — Working :**

Mr. C. K. BIRD, General Manager of the Eastern Region, British Railways.

SECTION II. — **Locomotives and Rolling Stock :**

Mr. A. PORCHEZ, Deputy General Manager, French National Railways, Member of the Permanent Commission of the Association.

SECTION IV. — **General :**

Mr. F. Q. DEN HOLLANDER, President Netherlands Railways, Member of the Permanent Commission of the Association.

The *Special Reporters*, chosen as usual amongst the Reporters (1), will be :

Question 1 : Mr. E. TENTI, Engineer.

Question 2 : Mr. R. F. HARVEY.

Question 3 : Mr. L. ANTOINE.

Question 1 relating in fact to two Sections (Section I and III), it was agreed to the request of the Italian State Railways suggesting to designate a co-reporter, Mr. Antonino RIGGIO, Engineer, Chief Inspector of the Permanent Way Dept, of this system.

Mr. GHILAIN gave also particulars about the publication of the reports in the Bulletin of the Association.

* * *

The Meeting heard the report of the Auditors, who checked the accounts of the XVIth Session, covering the years 1951, 1952, 1953 and 1954.

This report is favourable and in

(1) The List of Questions with the names of the Reporters was published in our *Bulletin* for April 1955, pp. 297/298.

consequence the accounts were approved without comments.

The provisional statement (up to the 30th September 1955) of receipts and expenditures for the year 1955 and the provisional budget for the financial year 1956 were submitted to the Meeting and duly approved.

After consideration of the present favourable financial position, the Assembly decided to maintain for the year 1956, the same amount of the variable contribution i.e. 0.28 Gold franc per kilometre, as during the last two years.

* * *

Information was also given concerning the changes which occurred in the memberships since the meeting of the 13th November 1954.

It must be mentioned especially the affiliation of the organisation « *Union d'Entreprises Suisses de Transport* ».

The Congress Association includes now 34 Governments, 10 Organisations and 101 Administrations with a total mileage of 470 000 kilometres (292 000 miles).

* * *

The General Secretary then gave particulars on the preliminary arrangements for the next Congress, which will be held in Madrid in 1958.

About 10 questions will be on the agenda of this Congress; they will be chosen from the proposals made by the members of the Permanent Commission, the Railway Administrations and affiliated Organisations. This agenda will be examined and finally approved by the Permanent Commission, at the meeting to take place at the Hague.

Mr. DE AGUINAGA, Director General de Ferrocarriles, Tranvias y transportes por Carretara, stated to the Assembly that the Spanish Government and the R.E.N.F.E. will take all necessary steps to ensure the 1958 Congress of a success at least as great as the Madrid Congress of 1930.

* * *

The meeting ended by the examination of various items concerning the activities of the Association since the last session of the Permanent Commission. The Assembly also approved the nomination of three Technical Secretaries and decided that the Association will send a delegation to the Buenos Ayres Session (April 1956) of the Pan-American Railway Congress.

The General Secretary, (s) P. GHILAIN. *The President*, (s) M. DE VOS.

List of Members of the Permanent Commission

OF THE

INTERNATIONAL RAILWAY CONGRESS ASSOCIATION

(22nd OCTOBER 1955).

President :

M. **De Vos** (2), Directeur Général de la Société Nationale des Chemins de fer belges; 19, rue du Beau-Site, Bruxelles.

Vice-presidents :

J. **Goursat** (3), Directeur de la Région du Nord de la Société Nationale des Chemins de fer français; 18, rue de Dunkerque, Paris (X^{e});

M. **Crem** (3), Directeur du Service de l'Exploitation de la Société Nationale des Chemins de fer belges; 17, rue de Louvain, Bruxelles.

Members of the Executive Committee :

E. **Dorges** (2), Secrétaire Général Honoraire aux Travaux Publics et aux Transports, Délégué Général du Ministre pour les Affaires Internationales au Ministère des Travaux Publics et des Transports; 244, boulevard Saint-Germain, Paris;

Sir John **Benstead** (3), Deputy Chairman of the British Transport Commission; 222, Marylebone Road, London, N.W.1;

Sir Gilmour **Jenkins** (1), Permanent Secretary, Ministry of Transport and Civil Aviation (Great Britain); Berkeley Square House, Berkeley Square, London, W. 1.

Ex-presidents of session, members ex-officio :

D^{r} Ing. G. **di Raimondo**, Directeur Général des Chemins de fer de l'Etat italien; Rome;

Ibrahim Fahmy **Kerim**; Le Caire;

D^{r} W. **Meile**, ancien Président de la Direction générale des Chemins de fer fédéraux suisses; Brügglerweg, 11, Berne;

General Sir Brian **Robertson**, Bart., G.C.B., G.B.E., K.C.M.G., K.C.V.O., D.S.O., M.C., Chairman, British Transport Commission, 222, Marylebone Road, London, N.W.1.

Members :

L. **Armand** (2), Président du Conseil d'administration de la Société Nationale des Chemins de fer français; 88, rue Saint-Lazare, Paris (IX^{e});

D^{r} Ing. A. **Attisani** (2), Chef du Service du Matériel et de la Traction des Chemins de fer de l'Etat italien; Florence;

Gamal-el-Din **Badawy Hamdy** (2), Directeur général des Chemins de fer de la République d'Egypte; Le Caire;

Sir John **Benstead** (already named);

R. **Besnard** (1), Chef de Service adjoint au Directeur général des Chemins de fer et des Transports, Ministère des Travaux publics et des Transports; 244, boulevard Saint-Germain, Paris;

David **Blee** (2), Traffic Adviser, British Transport Commission; 222, Marylebone Road, London, N.W.1;

Ch. **Boyaux** (1), Directeur Général de la Société Nationale des Chemins de fer français; 88, rue Saint-Lazare, Paris (IX^{e});

Dipl.-Ing. A. **Brill** (2), Ministerialdirektor, Leiter der Maschinentechnischen- und Beschaffungsplanungsabteilung der Hauptverwaltung der Deutschen Bundesbahn; Friedrich-Ebert-Anlage, 43-45, Frankfurt (Main);

A. **Brouckaert** (1), Directeur du Service du Matériel et des Achats de la Société Nationale des Chemins de fer belges; 17, rue de Louvain, Bruxelles;

E. **Clarembaux** (2), Directeur du Service de la Voie de la Société Nationale des Chemins de fer belges; 17, rue de Louvain, Bruxelles;

R. **Claudon** (2), Inspecteur Général des Ponts et Chaussées, Vice-Président du Conseil d'administration de la Société Nationale des Chemins de fer français; 88, rue Saint-Lazare, Paris (IX^{e});

D^{r} R. **Cottier** (3), Directeur de l'Office Central des Transports Internationaux par Chemins de fer; Berne;

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(1) Retires at the 17th session.
(2) Retires at the 18th session.
(3) Retires at the 19th session.

T.C. **Courtney** (2), Chairman of the Coras Iompair Eireann; Kingsbridge Station, Dublin;

M. **Crem** (already named);

Csanadi (3), Directeur Général des Chemins de fer de l'Etat hongrois; Budapest;

Dr Ing. A. **Cuttica** (2), Vice-Directeur Général des Chemins de fer de l'Etat italien; Rome;

Ph. **Dargeou** (2), Directeur Général Adjoint de la Société Nationale des Chemins de fer français; 88, rue Saint-Lazare, Paris (IXe);

J. **de Aguinaga** (1), Director General de Ferrocarriles, Tranvias y Transportes por carretera; Madrid;

F.Q. **den Hollander** (3), Président des Chemins de fer néerlandais, S.A.; Utrecht;

M. **De Vos** (already named):

M. **Dias Trigo** (3), Directeur des Services d'Exploitation et du Matériel de la Direction des Transports terrestres au Ministère des Travaux publics et des Communications du Portugal: Lisbonne;

G.H. **Dijkmans van Gunst** (2), Directeur Général des Transports au Ministère des Transports et du Waterstaat; La Haye;

Dr Ing. G. **di Raimondo** (already named);

E. **Dorges** (already named);

Sir John **Elliot** (3), Chairman of the London Transport Executive; 55, Broadway, Westminster, London, S.W.1;

W.T. **Faricy** (2), President, Association of American Railroads; Transportation Building, Washington, 6. D.C.;

Fathy Radwan (3), Ministre des Communications d'Egypte; Le Caire;

Ing. A. **Florena** (3), Chef du Service du Personnel et des Affaires Générales des Chemins de fer de l'Etat italien; Rome;

Prof. Dr.-Ing. E. **Frohne** (3), Erster Präsident der Deutschen Bundesbahn; Friedrich-Ebert-Anlage, 43-45, Frankfurt (Main);

J.M. **Garcia-Lomas** (1), Directeur du Réseau National des Chemins de fer espagnols; Madrid;

J. **Goursat** (already named);

K.W.C. **Grand** (1), General Manager, Western Region, British Railways; Paddington Station; London, W.2;

Dr H. **Gschwind** (1), Président de la Direction Générale des Chemins de fer fédéraux suisses; Berne;

R. **Hoens** (3), Directeur Général de la Société Nationale belge des Chemins de fer vicinaux; 14, rue de la Science, Bruxelles;

Dr A. **Huyberechts** (1), Directeur Général Adjoint de la Société Nationale des Chemins de fer belges; 17, rue de Louvain, Bruxelles;

M. **Jacobshagen** (1), Ministerialdirektor, Leiter der Betriebsabteilung der Hauptverwaltung der Deutschen Bundesbahn; Friedrich-Ebert-Anlage, 43-45, Frankfurt (Main);

Sir Gilmour **Jenkins** (already named);

Manabu **Kanematsu** (1), Directeur du Service des Affaires Etrangères, Chemins de fer Nationaux du Japon; Chiyodaku Tokio;

Ibrahim Fahmy **Kerim** (already named);

A. **Kriz** (2), Ingénieur, Conseiller Supérieur de Section au Ministère des Communications de la République tchécoslovaque; Prague;

R. **Kunz** (1), Directeur de l'Office fédéral des transports;Berne;

Dr N. **Laloni** (3), Directeur Général Adjoint des Chemins de fer de l'Etat italien; Rome;

F.L. **Lehtinen** (2), Directeur Général Adjoint des Chemins de fer de l'Etat de Finlande; Helsinki;

R. **Lévi** (1), Directeur des Installations fixes de la Société Nationale des Chemins de fer français; 42, rue de Châteaudun, Paris;

W.H. **Maass** (2), Advisory Engineer to the High Commissioner for the Union of South Africa; South Africa House, Trafalgar Square, London, W.C.2.;

M. **Malderez** (1), Secrétaire Général du Ministère des Communications de Belgique; 17*a*, rue de la Loi, Bruxelles;

Ing. F. **Marin** (2), Vice-Directeur Général des Chemins de fer de l'Etat italien (*retired*); Rome;

Dr W. **Meile** (already named);

Moussa Arafa (2), Sous-Secrétaire d'Etat au Ministère des Communications d'Egypte; Le Caire;

J.P. **Musquar** (3), Directeur Général de la Société Nationale des Chemins de fer Luxembourgeois; 17, rue du Nord, Luxembourg;

P. **Nolet de Brauwere** (2), Secrétaire Général de la Société Nationale des Chemins de fer belges; 17, rue de Louvain, Bruxelles;

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(1) Retires at the 17th session.
(2) Retires at the 18th session.
(3) Retires at the 19th session.

G. **Olivier** (3), Administrateur de l'Office National pour l'achèvement de la Jonction Nord-Midi; 26, avenue Milcamps, Bruxelles.

G. **Pande** (2), Chairman, Railway Board, Ministry of Railways, Government of India; New Delhi;

A. **Peña Bœuf** (2), Président du Conseil d'Administration du Réseau National des Chemins de fer espagnols; Madrid;

Dr Ing. V. **Perrone** (3), Inspecteur Général Supérieur de la Motorisation Civile et des Transports concédés (*retired*); Rome;

A. **Porchez** (1), Directeur Général Adjoint de la Société Nationale des Chemins de fer français; 88, rue Saint-Lazare, Paris (IXe);

Abdel Moneim **Rashad** (2), Directeur Général Adjoint des Chemins de fer de la République d'Egypte; Le Caire;

X. **Remy** (3), Directeur des Chemins de fer Fribourgeois et Président de l'Union d'Entreprises suisses de Transport; 3, avenue de Pérolles, Fribourg;

General Sir Brian **Robertson** (already named);

Dr M. **Schantl** (2), Directeur Général des Chemins de fer fédéraux autrichiens; 9, Elisabethstrasse, Vienne I;

Dr. F. **Schelp** (2), Präsident der Deutschen Bundesbahn; Friedrich-Ebert-Anlage 43-45, Frankfurt (Main);

H.E. **Simpson** (3), President, Baltimore and Ohio Railroad Company; Baltimore, Md.:

P.E.N. **Skov** (2), Directeur Général des Chemins de fer de l'Etat danois; 40, Sölvgade, Copenhague, K;

H.E. **Stokke** (1), Directeur Général des Chemins de fer de l'Etat norvégien; Oslo;

Ing. J. **Švagel** (1), Directeur de l'Institut des Chemins de fer Yougoslaves; Belgrade;

J.C.L. **Train** (1), Member of the British Transport Commission; 222, Marylebone Road, London, N.W.1;

J. **Tuja** (3), Secrétaire Général de l'Union internationale des Chemins de fer; 10, rue de Prony, Paris;

E.G.J. **Upmark** (1), Directeur Général des Chemins de fer de l'Etat suédois; Stockholm;

F. Perez **Villamil** (1), Directeur Adjoint du Réseau National des Chemins de fer espagnols; Madrid;

W. **White** (2), President, Delaware & Hudson Railroad Corporation; 230, Park Avenue, New York 17;

Lt.-Col. G.R.S. **Wilson** (1), Chief Inspecting Officer of Railways, Ministry of Transport and Civil Aviation; Berkeley Square House, Berkeley Square, London, W.1;

N... (1) Argentine.
N... (2) Argentine.
N... (1) Bulgaria.
N... (1) China.
N... (2) Great Britain.
N... (3) Great Britain.
N... (3) New-Zealand.
N... (3) Poland.
N... (1) Rumania.
N... (1) Switzerland.
N... (3) U. S. A.

Honorary President : F.H. **Delory,** Directeur Général honoraire de la Société Nationale des Chemins de fer belges; 2, avenue Rév. Clément, Rixensart.

Members of Honour : O.V.S. **Bulleid,** Chief Mechanical Engineer, Coras Iompair Eireann; Inchicore Works, Dublin.

R. **da Costa Couvreur,** ancien Président du Conseil supérieur des Travaux publics au Ministère des Travaux publics et des Communications du Portugal; Alameda das Linhas de Torres, 149, Lisbonne;

P. **Ghilain,** Directeur honoraire du Service du Matériel et des Achats de la Société Nationale des Chemins de fer belges, Secrétaire Général de l'Association; 19, rue du Beau Site, Bruxelles.

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The Rt. Hon. Lord **Hurcomb,** G.C.B., K.B.E., Chairman, British Transport Commission 1947-53; 47, Campden Hill Court, Campden Hill Road, Kensington, London W. 8;

U. **Lamalle,** Directeur Général honoraire de la Société Nationale des Chemins de fer belges, professeur émérite de l'Université de Louvain; 27, rue de l'Aurore, Bruxelles.

(1) Retires at the 17th session.
(2) Retires at the 18th session.
(3) Retires at the 19th session.

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General Secretary : **P. Ghilain.**

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